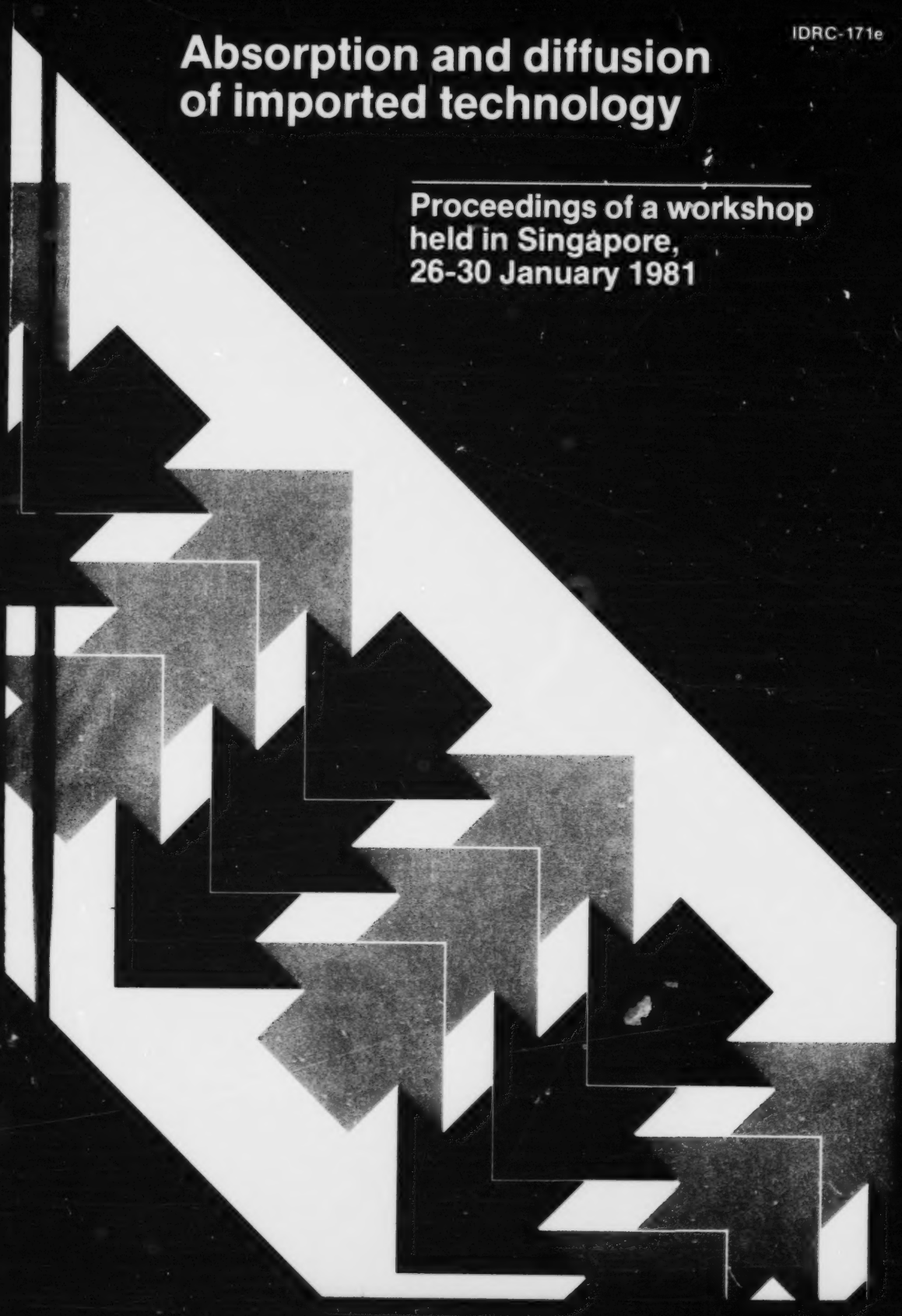
IDRC-171e

Absorption and diffusion of imported technology

Proceedings of a workshop held in Singapore, 26-30 January 1981



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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

IDRC, Ottawa CA

IDRC-171e

Absorption and Diffusion of Imported Technology : proceedings of a workshop held in Singapore, 26–30 January 1981. Ottawa, Ont., IDRC, 1983. 112 p. : ill.

Science policy . technology transfer . choice of technology . technological change . South Asia . Indonesia . Korea R. . Philippines — small-scale industry . textile industry . self-reliance . employment opportunities . foreign investments . case studies . comparative analysis . list of participants .

UDC: 62.001.1

ISBN: 0-88936-298-X

Microfiche edition available

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Foreword

The present volume collects together a number of papers given at the final workshop (January 1981) of a comparative project concerned with the absorption and diffusion of imported technology in Asia.

The project has a long history. At the first meeting of the Association of Development Research and Training Institutes of Asia and the Pacific (ADIPA) held in 1974, researchers called attention to the growing importance of imported technology to Asian economies and the relative lack of knowledge about the process by which it was adopted, absorbed, and diffused within national economies. By the time of ADIPA's Canberra meeting (1976), a number of research institutions had proposed a network project to the International Development Research Centre (IDRC) to compare the various patterns of adoption and diffusion in Asia. In September 1976, the Centre helped sponsor a project identification meeting in Karachi, which reviewed the proposals and established comparative guidelines for the research. Because the researchers needed to examine other work and their own approaches more fully, the Centre sponsored a research workshop for a period of 10 weeks held and run by the Science Policy Research Unit at the University of Sussex. The outcome of this workshop, which was led by Martin Bell, provided the framework for the subsequent research.

The research, which commenced in the last quarter of 1977, was undertaken by teams from the following institutions: Investment Advisory Centre, Karachi, Pakistan; Management Development Institute, Delhi, India; Marga Institute and the (then) National Institute of Management, Colombo, Sri Lanka; Institute of Economic Research, Seoul, Korea; Institute of Business Administration, Dacca, Bangladesh; and National Science Development Board, Manila, Philippines. The researchers met in three working meetings during the course of the research to see if there was a comparative base from which policymakers could draw lessons from the technology transfer process. The research workshops took place in Colombo (1979), Delhi (1980), and Singapore (1981).

The papers in this volume represent the work of the group to January 1981. The papers are only a small part of the work undertaken by the researchers and interested readers may wish to get in touch with the researchers or institutions directly in order to reach the final report. The papers show the importance of the subject for understanding current economic growth and development as well as the difficulty of establishing one common comparative approach. By the time of the Singapore workshop, there was greater emphasis, as the papers show, in trying to explain the adoption and diffusion process in particular national sectors rather than in establishing the similarities and differences across nations. As with most networks, comparative learning proved to be more feasible than

comparative research, so that lessons between countries are likely to have widened the horizons of researchers rather than directly influenced their results. The meetings proved to be a valuable way of seeing differences rather than similarities.

Present and former IDRC staff associated with the project – Geoffrey Oldham, Martin Bell, Roger Young, Andrew Barnett, and A.D. Tillett – would like to thank the researchers for teaching them about technology policy in Asia.

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Introduction

Technology policy is an amorphous subject, respected more in spirit than body, in principle than application. For many governments and ministries, technology policy is a second-order issue, dependent upon the resolution of more pressing first-order problems of balance of payments, fiscal policy, employment, and inflation. When the first-order problems are tentatively resolved, technology policy might receive recognition in the form of either a government plan or a minister's speech encouraging people to use appropriate or indigenous technology; thereby enabling them to cut down on import and energy costs. In the day-to-day routine of administration, however, technology policies play a minor role as governments struggle with price controls, validating documentation, and slowly applying or delaying policy decisions.

To understand the behaviour that technology policy sets out to modify, it is necessary to find a suitable link between first- and second-order problems, i.e., to understand how first-order decisions constrain and shape second-order decisions and then how second-order decisions influence, in turn, future first-order decisions. In practice, for the analysis of technology policy, it requires that the overall economic environment be taken into account so that the growth of first-order aggregates are specifically related to technological decisions. In the past, technology policy studies have set out to make such a link but very often they delineate the problem and expect the reader or policymaker to make the link. One large study, which established much of the vocabulary for the field, the science and technology policy instruments (STPI) study,[1] limited itself to defining *implicit* and *explicit* technology policies across eight nations and found, to its surprise, that implicit policies carried greater weight.

The absorption and diffusion of imported technology (ADIT) network is examining the way that technology from outside a country is used and diffused, with the implication that the process of importation is a government decision. With the completed studies, it appears that the evidence would lead to a revision of this initial assumption because first, the decisions are linked to outside interest, such as bilateral agencies, and second, the interest to expand depends upon the growth and prosperity of firms; which in turn depend upon present and expected market conditions. Therefore, it is worth changing the focus and approaching the problems from the other side, i.e., looking at the way in which the economic environment — the first-order problems for technology policy — are analyzed and then linked to business conditions.

The three perspectives that might help provide a link involve capital, markets, and controls. Capital has long been the subject of dispute, in the sense that financial capital and physical capital are defined as cash or credit for investment and machinery, equipment, and other bits and pieces. Government monetary policy, for example, affects the price of credit and, therefore, the opportunity

[1]International Development Research Centre (IDRC). 1975. The science and technology policy instruments (STPI) project. Ottawa, Canada. IDRC, IDRC-050e, 12p.

cost of investment. Although there is a ruling price for investment, firms that cannot dominate the market become price takers. A price taker, in contrast with a price maker, has to chose an evaluation for its investment and this evaluation at the microlevel becomes intimately linked with the cost of money in the macromarket. The link is there, between macropolicies and microdecisions, even though tracing the path is sometimes tortuous. The relevance of looking at both the macro- and microaspects of the money market is unimportant for a number of stable, relatively large firms. For smaller firms, however, that are making investments larger than might be expected — and recall that on a world scale most developing country firms are small — the managers or owners want some guarantees.

The best guarantee is to have the support of the government or, better still, be part of the government, for risks can then be transferred to the tax system. A second solution is to receive aid money through the government or as a joint venture so that the interest rate is less than the market rate, with the choice of machinery and equipment linked to the donor. A third solution is to rely on either strong government support to suppress competition or to ensure that the firm can dominate the market. The government's policy toward capital formation, therefore, is linked to the range of decisions and risk that private firms undertake or are willing to accept.

The second perspective linking first- and second-order problems is that of the market. Investment choices have to have a view on their pay-back period, which is itself based on future costs and output. Firms that plan to use the domestic market only tend to be smaller than those that plan to use the international market. At one time, policies toward the kind of market firms wished to participate in were thought to evolve naturally. It appears, however, that this evolution has been replaced by a more direct approach toward world markets. Firms in countries such as Korea and the Philippines are choosing to enter the world market; certainly they see the domestic market as a cushion, but because so many of them are small, they realize that they cannot employ large-scale technologies without exporting. The domestic economies of most developing countries have grown too slowly to support firms in the chemical and steel industries, for example, which do not have a minimum efficient size. Minimum efficient sizes do not stand still; they have grown as technology has developed, providing cheaper unit production costs and the possibility of greater profits. There is a caveat, which is that companies, to enter the world market, and who wish to use a plant of a minimum efficient size, have to be run efficiently. The history of industry in many of the network countries is littered with schemes that promise world markets but fail because running a plant efficiently takes more than bureaucratic skill. They then fall back on the domestic market and to make a profit, if this is demanded of them, are highly underutilized or require some kind of market protection.

The third perspective that links first- and second-order problems is that of prices and, particularly, price controls. Poor countries that are both diversifying their economy and feel an obligation toward the bulk of the population have a penchant for controlling prices. Basic needs become luxuries unless they are within the reach of average and less than average income groups. Governments are responding to popular pressure and economic needs with subsidies, price fixing, and tariffs, which have the effect of reducing some prices relative to others, thereby encouraging money and profit seekers to move from one area of the economy to another. In Latin America, price controls on food subsidize the urban population but have the effect of reducing investments in agriculture and

offering some golden opportunities in industry. Price controls in some form or another cannot be avoided in developing economies that have a money economy, but governments must consider how this will effect investment decisions and, particularly, profit expectations.

Most governments in developing countries see economic growth as essential to their future welfare. What kinds of growth do they pursue? How do they pursue growth and what implications does this have for technology policy? It is possible to specify three models that cannot be treated separately but from their political and social consequences, indeed in one sense they are the political and social consequences, stand in varying degrees of contrast with each other. The first model is that of the *open economy*, which takes world price signals as domestic price signals and, therefore, allocates its resources for investment and production in terms of shifts in world demand. There are few, if any, open economies in the world, although there are some tentative experiments in Latin America and Asia. Developing countries have avoided such models, given a popular rather than dictatorial choice, partly because governments and industry expect stable earnings and employment, partly because the world market is fickle, but most importantly because the world market is so unfair. To work, everyone has to abide by the same rules and this does not happen because some economies are more powerful than others and because changing the rules is their prerogative. Developing countries that succeed too well, e.g., Japanese cars or Brazilian shoes, find industrial markets closed to them so that market and investment time are not synchronized.

The *infant industries model* is quite distinct. Here, the private or public sector or both agree to build up productive facilities through protecting their market. Prices are then set in terms of the domestic market alone, even though the intention may be to release protection later on. This is the most common model of economic development and it is worth reflecting that until World War I the American economy was highly protected. Investment decisions that may be taken with an initial responsibility, soon have a way of assuming that domestic prices are the only prices to be considered and if this results in a wide gap between world and national prices then many decisions, including the choice of technology, are dependent upon a continuation of protection.

The third model, often confused with the first, is that of *export-led growth*. Governments and industry search for products that have a degree of comparative advantage; i.e., may be sold on the domestic market but earn their bread in the world. Export-led growth, to be sustained, must be based on a set of government decisions to ease the way for its development. In the case of Japan and Korea, there is a combination of government encouragement, financial support, and engineering ambition that identifies export areas as target markets.

Although loosely presented, the three models have implications for technology policy. In open economies, there is unlikely to be a technology policy because the world market will decide; with infant industries, ongoing production requirements can limit choices after the initial investment; in export-led markets, there is a conscious choice about the way national income is to be earned. Although these conclusions are stark and intended for refinement, they allow some cognizance to be taken of the role of first-order problems and, thus, where the countries being studied fit in. One refinement can be found in the use of the words importation, adaptation, and diffusion.

The premise behind the word *importation* is that the product or process used for the final or intermediate product is not developed within the country and there is an advantage, normally price, in not doing so. Here, one must be very

careful in distinguishing what is being imported; for example, a complete production system such as a digital telephone switching system or telephone exchange that comes as a package; a particular process, distinct from the system, but components that fit into a larger whole; discrete pieces of equipment and machinery that, up to a point, work with any appropriate system. The distinctions have importance for the second word, *adaptation*, because the premise behind this word is that there has been an experience of learning to use the imported technology. Adaptation implies that a technology has been so understood that it can be handled by the importing firm and adapted to its own particular use. Adaptation depends on two factors: the nature of the imported product or process, and the resources available to permit successful adaptation of the technology. Certain technologies are difficult to adapt either because there is a natural entry barrier such as knowledge or cost, or because the technology is protected through patents and know-how agreements. There is, however, a wide spectrum of technologies that are adapted and, therefore, subject to improvement or adaptation to local conditions. In addition, the resources must be available within the country to undertake the learning process so that firms can draw not only on pools of cash but engineering skills and operational experimentation. Government policies can assist this process marginally through tax incentives, credit allowances, or the development of joint venture agreements, which have been seen by the public sector as answering their doubts regarding outside control and technological obsolescence. Not all adaptation implies learning, however; repetition of imported production systems, as in the case of the textile mills in Sri Lanka, can lead to production systems that have only a bureaucratic, not technical, connection between them, even though they are under the same ministry and producing similar goods.

The *diffusion* process assumes that a given technology has a proven manufacturing capacity and that its known advantages compensate for the capital or equipment replacement that results. Diffusion of major technologies, particularly in developing countries, is limited by the extent of the market. For a particular process, such as automatic loom machines, it is likely that the diffusion process is the result of competition (comparative costs), monopoly power (producer dominance), or government encouragement (risk underwriting).

In any industrial structure, it is possible to define three types of manufacturing subsectors that because of their characteristics lead to different opportunities and constraints for the entrepreneur.

The first subsector consists of *established industries*, which are manufacturing facilities producing goods for common wants or basic needs, such as food processing, furniture, textiles, and clothes. They tend to have a low capital labour ratio, low relative productivity, and they expand as a function of disposable income. The second subsector, *emerging* industries, rely upon the economies of scale in the widest sense of the word. The common pattern of an emerging industry is reliance upon the manufacturing multiplier, the need of established industries to contract out equipment and technical services often at a very modest level. Small companies that repair machines often proceed, with encouragement, to produce simple and then more sophisticated parts until they finally learn to produce, for example, a simple milling machine. Firms producing in one sector may find production bottlenecks that force them into learning about processes and machinery in other sectors until they decide that they have learned enough to market the machines themselves. Many developing countries have passed laws about the degree of national inputs to be contained in

a final product such as an automobile. They have done so because it is a way of increasing employment and local business as well as skills that can be a guaranteed given market. In Latin America for example, most of the countries specifically require foreign companies to take a minority position in the automobile sector. Emerging industries are built, therefore, on a combination of Hirschman's linkeages and Rosenburgs' "compulsive sequences"; emerging industries are implicit production steps made explicit because of market growth.

The third category in this simple industrial structure is *new* industries, which are supported, normally by the government, because of strategic interests or future needs. The nuclear or aircraft industry are examples of such industries in developing countries.

Taking these categories we can now see the implications of the importation, adaptation, and diffusion of technology for established, emerging, and new industries.

For an established industry with static conditions, i.e., no real increase in market demand, the importation of technology is likely to result in the substitution of fewer but more efficient machines, which in turn will lead to labour displacement. If this is the case, then a slow rate of importation, slow adaptation, and little or no diffusion because of major constraints on changing the existing structure might be expected. In the case of emerging industries, again assuming no real increase in market demand, the importation of equipment is likely to depend on cost advantages for the producer for two separate reasons. First, the plant or industry is likely to have a steadily increasing cost curve as the production reaches the margin, which will, of course, be further to the left than in a growing economy. Second, producers are likely to search for cost reductions in inputs, e.g., raw material substitution. Importation of technology will be slow, adaptation will only take place in the leading plants, and there is likely to be little or no diffusion until the indigenous technical changes, e.g., raw materials, have been worked out. If these conditions apply, technical changes are likely to have the advantage of increasing labour because costs internal to the plant have moved toward greater capital investment. New industries, because they come from a perception of national prestige or strategic need, assume risks that are often outside the private calculation of profitability and, therefore, depend upon some form of government support. Plants are few and the advanced nature of the technologies relative to the remainder of the industrial structure are unlikely to be diffused in developing countries.

If these static assumptions are released and demand increases, where is the increased demand to come from? For many of the ASEAN countries, it has been the product of increasing exports which, if export growth is sustained, release the constraints on technical change. Expanding markets encourage the importation, adaptation, and diffusion of technology; static markets discourage such actions because they lead to a rapid change in the industrial structure and labour displacement.

Neither firms nor governments can see into the future, so they make assumptions regarding the capacity of industries to export, which may, of course, not turn out to be true. Because growth has to be initiated before it becomes self-sustaining, it seems that the governments of this region have used a combination of the three different models, providing the trade-offs are available, for the three different industrial types.

In the case of established industries, governments use the free-market model, allowing price signals, within limits, to determine the importation, adaptation,

and diffusion of technology. In the case of emerging industries, lesser developed countries (LDCs) assume export-led growth, which reduces the cost of production so that the importation, etc. depends on market demand. New industries are treated like infant industries – higher costs and tariffs – with the assumption that technological importation will be restricted.

There is, therefore, a mix of models that depends on exports; if export growth is removed then either the industries rely on domestic markets or they compete in similar product lines with other LDCs or LDC markets themselves become export markets. Examples of these policies are found within the countries studied in the network: India depends on the growth of the domestic market for more sophisticated textile and clothing products; Sri Lanka is now competing with other LDCs in third country markets; and Korea is selling products to Middle East countries.

If it can be agreed that there is a relationship between the type of industry, associated technology patterns, and government policy and, in turn, the relationship of all three variables to the export market, then prognostications for technological spread and deepening will depend on economic growth in the 1980s and it is likely that the slowdown in world trade is likely to alter the relationship between them all.

In the period of world economic expansion that followed World War II, world trade grew at 8% (1950–1973), whereas trade in developing countries grew at 6%. Because there is a close relationship between both, a reduction in the import rate of the industrialized economies to 4% must mean a decline in the growth rate of the less developed countries. This could be coupled with even greater protectionism from developed countries such that developing country exports increase at a much slower rate than in the past. This would not only be a serious blow to the aspirations of many countries but would lead to different patterns of exports between developing countries as well as calling for different economic and technological policies. First-order problems will dominate because countries, particularly those importing their energy requirements, will be plagued by a shortage of funds for investment, trade deficits, and balance of payments shortfalls.

The task of technology-policy research in the 1980s, therefore, is to understand how, given the constraints on growth faced by developing countries, they can use technology to sustain their necessary welfare goals. To do so, one must not just have a clear idea of past technical change but a sense of domestic trade-offs and a vision of what is happening in the world. Shifts in economic power are likely to have a considerable impact on how governments can sustain growth and continue development, which requires both information as provided by this network and also imagination and determination.

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ADIT: A Review

The conclusion of the final workshop, marking the formal closure of the research project on absorption and diffusion of imported technology (ADIT), supported by the International Development Research Centre (IDRC), forces one to go back to the beginning of this exercise to retrace the research process and examine the results achieved. The process began almost 6 years ago at the second biennial meeting of the Association of Development Research and Training Institutes of Asia and the Pacific (ADIPA). ADIPA had been formed only a short while before to provide a mechanism to link together researchers within Asia and to share their research results. It was an attempt to increase the flow of knowledge between the countries of the region: to overcome the prevailing pattern wherein research from one Asian country flows to another largely through developed-country institutions and journals, and, therefore, flows only if it is picked up in the first place by researchers outside the region. The ADIPA meeting of researchers and heads of research institutions broadly identified the area of change, innovation, adaptation, and diffusion of technology within the countries of the region as a research topic on which little emphasis had been placed and one deserving of a collaborative research effort by several research institutions in the region.

Researchers at 10 different institutions, in eight countries of the region, were originally interested in the theme of the research and proceeded to develop the idea further. The final network was composed of seven research institutions in six countries — Bangladesh, Sri Lanka, South Korea, Pakistan, Philippines, and India.

The countries represented in the network are at different stages of industrialization, have adopted different development goals and economic policies, and have enormous differences in sociopolitical conditions, historical traditions, resource endowments, and structures and sizes of their markets. All of these factors can be expected to make a difference in the relationships between the technology-related factors and other developmental variables. They also contributed to obvious and necessary differences in the perspectives and focus of each research group that participated in this network. These roots of the research and researchers have shaped the entire process and objectives of the research effort and have contributed to it certain strengths as well as limitations.

The intellectual roots of the research came from an acceptance of the existing material poverty in the six countries, which has both as a cause and an effect the insufficient ability to produce goods for the modern market. A necessary and critical input for overcoming this is the availability of appropriate techniques for production. Yet another given condition is the dependence of these societies on foreign technologies that had been developed for and adapted to the size of the

market and requirements for specialization in their countries of origin. From these more-or-less accepted facts came a belief that one of the more negative effects of technological dependence is the implied lack of an endogenous process of change. Although, in the common calculus of economics, such a deficiency would be relegated to a second-order effect, such second-order effects can have a serious impact, particularly because the time dimension in the micro- and macrolevels may well be different by an order of magnitude.

It is this belief and the observation that, although in the countries involved in the network some work had been done on issues relating to the transfer of technology on a national level (e.g., sources of technology, costs incurred, restrictive practices), very little work, if any, had proceeded to examine the post-transfer process in a systematic fashion.

The task set by the researchers was an ambitious one, aimed at exploring further the implications of the findings of three major sets of studies that are of significance in the area of science and technology policy research. The first is the large international study supported by IDRC on science and technology policy instruments (STPI). This set of studies had just begun to produce a significant amount of data on the ways in which such policies could be said to be organized, both explicitly and implicitly, in eight developing countries. The reports generated by the STPI group of studies immediately raised questions on costs, benefits, and impacts of using such alternative policy options.

The second set of studies can be grouped under those supported by the United Nations Conference on Trade and Development (UNCTAD). These studies explored in some detail the direct costs, and estimated some of the indirect costs, of technology-transfer agreements entered into by developing countries. These studies highlighted some of the restrictive clauses and inequities forced upon the recipients in many of these agreements. This genre of research, with its foreboding projections of levels of future payments for technology, raised a number of questions on the value of the technology transferred. It also raised the possibility that, although the recipients may now be in a relatively weak negotiating position, the key variable for the future depended on efforts to improve technological capability, thereby changing relative bargaining positions.

The third set of studies, which rely largely on the experience of western industrialized nations, have involved more detailed analysis of technical change and innovation at the level of the firm, branch of industry, or sector. These studies have examined the nature of such changes, variables that appear to affect the rates of change, and micro- and macrolevel economic impacts of such change.

The purpose of the project was to understand the nature of technical change and the influence of technology on the productive capacities of a number of Asian countries, to go beyond generalized hypothesis on technology policy and examine its role in particular sectors, and then to use the empirical evidence to attempt to develop policy implications for national governments. On a policy-research dimension, such a procedure starts off by linking the first-order problems of finance, employment, trade, macropolicies, and their effects on the particular industry with the second-order, technology-related phenomena of technological capability, technical change and innovation, technical behaviour, etc. Because general and sectoral policies usually combine to form a unique set of circumstances for each industry and sector, it can be expected that the true extent of available policy options, as well as their limitations, can be assessed

more precisely by conducting the study within specific industrial branches. This approach also allows a greater range of diversity of interests to be sustained within a common framework. By conducting the study at the level of the industrial complex or branch and the groupings of firms operating within this level, the inherent technical characteristics and logic of the industry can be expected to place their own ordering on the studies and ensure a certain continuity and commonality to them.

The research and collaboration process by the different teams began with a workshop at the Science Policy Research Unit (SPRU) of the University of Sussex.[1] During this workshop, the research agenda was planned, for the most part, and a process for research collaboration was evolved. Procedurally, the project design provided for up to four working meetings during the 2-year period of research to discuss progress and problems, and to learn from the group effort. To economize on resources, it was agreed by the researchers to share the coordination role among themselves during the progress of the research.

At the Sussex workshop, the researchers agreed that, thematically, all of the groups wished to examine the consequences and developments within the domestic economy subsequent to the initial technology transfer. All of the teams agreed to select the textile industry as one of the industries to be examined in each country, an industry of some importance to all participating countries, which would provide a minimum common core to all of the studies. The teams were free, however, to include other industries in their study, with most of them doing so.

The project started with the acceptance that, in the countries involved, the techniques of production, both embodied and disembodied, had been imported at some point in the recent past. It was also accepted a priori that the need for technology imports for the industry would probably continue. It would be the subsequent process of developments in the domestic sector, the mechanisms and factors influencing technical change, and the micro- and macrolevel impacts of such change that would provide the overall context for the research. Within this broad area, a number of more specific questions were posed for the research effort. These questions form four groups.

The first group is composed of questions on the accumulation of technical capability. How can the technical capability of a firm, industry, or sector and its change over time be measured? How is technical knowledge absorbed into the productive system? What interrelationships can be found between technical capability and its improvement with firm and industry characteristics, and between the process of technology acquisition and its utilization? What are the effects of learning by doing, government policies, and market structures?

The second group is related to technical characteristics and behaviour. What is the nature of the technical change, innovations, and adaptations taking place in the selected industry? What are their distinguishing characteristics, and how do these characteristics affect the availability, sources, and costs of technology

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[1]It is appropriate here to note, with appreciation, the contribution of C.H.G. Oldham, Associate Director of the Science and Technology Policy Program of IDRC at that time. He played a major role in ensuring that the researchers were able to design the objectives and methodology of the research and the collaboration process in their own way. Thanks are also due to Martin Bell and Kurt Hoffman of SPRU, who coordinated the research planning workshop, introduced the researchers to literature about which they had not been aware, and, over long discussion, contributed substantially to the logic of the research.

supply? How are local participants, i.e., firms, government agencies, and research and development institutions, involved in this process? Are there any significant inefficiencies in resource utilization using the available techniques of production and, if so, what are their causes?

The third set of questions addresses the economic implications. What relationships can be established between technical capability, innovations and adaptations, and microeconomic variables (such as the quantity, quality or cost of output, local resource use, market shares, etc.) and macroeconomic variables (such as employment, foreign exchange generated or used, income, etc.)?

The final group of questions is related to government policy. What are the relevant micro- and macrolevel government policies that have an impact on the markets, inputs, outputs, rate of growth, research and development policies, and technological change within the industry and individual firms?

As mentioned earlier, the agenda for the research was an ambitious one, and the only concession the project design made for resource and time constraints was to limit the study to a few industries. There are important reasons for keeping the agenda as wide as that described above when the examination of any one of the set of interrelationships discussed earlier would have been more defensible as an academically sound piece of research. One of the reasons is the well-known, complex set of interactions and relationships among technology, its source, the recipient, the process of its transfer, the environment of its origin and use, and the resultant impact on the development process.

There existed a large body of literature that looked at important components of the technical-change process in industrialized countries. Also, another body of literature existed that addressed itself to the process of transfer of technology from the industrialized to the less industrialized countries, together with attendant costs and benefits. However, in the countries where the research was to be carried out, there was a significant lack of research on the nature and effects of technical change, on the interrelationships among the various causal factors, and on the roles of technology transfer and indigenous technological development within a much larger set of interactions. With an awareness of the dimensions of the research task went an awareness that the effort would, in any case, be a first and partial attempt to provide answers to problems that will exist for a long time, and that the effort would be successful if it could identify some of the major interrelationships and some of the more useful policies and their limitations.

The research project was successful at the most prosaic level in that all of the research groups that started with the research saw it through to completion and produced one or more substantial pieces of research, described in the reports prepared by the teams. Although the summary/synthesis papers presented at this final research meeting try to capture all of the findings, they have almost necessarily been unsuccessful in conveying the details and richness of many of the reports. With this background it would be quite presumptious on my part to attempt another summary of the research results of all of the teams. Rather, this section should be seen as a personal commentary by one individual on the research process in which more than 20 others have participated, together with a selection of the research results that fit into such a personalized statement.

The simple exercise of receiving research funds, organizing research teams at different institutions, and holding periodic research progress meetings, which would all be relatively prosaic matters in the rich countries, turned out to be difficult and complex in itself. Due to varying government administrative procedures in the six countries, the research teams could not start at the same

time. The research, originally designed to last for a period of 2 years, was actually in progress for more than 4 years. Thus, at one extreme, the Bangladesh team had completed its period of research before the group from India received formal approval to proceed. This, naturally, prevented the teams from meeting at 6-month intervals as planned. When the meetings did take place, the coordination of the research was difficult and the exchange of ideas and methods more limited than would have occurred otherwise. In most of the countries represented in the network, there were important political changes during the course of the research, often with major shifts in policy emphasis. Finally, due to disturbed political conditions, one of the research groups was only able to attend the first planning meeting and the final meeting. During the entire course of the study they did not benefit from the work being carried out by the others.

Some of the other impediments faced by the researchers came from their own institutional environments. These ranged from a lack of adequate library facilities and information resources to problems encountered in keeping intact the groups of researchers over the unexpectedly protracted period of research. The meetings always seemed, at the time, to have many more moments of frustration than progress. One problem that the network did not need was the tendency, adopted by many research establishments in Asia, for a senior person uninvolved in the research to replace the actual researcher at meetings that were considered prestigious in some way.

In spite of all of these difficulties, I would conclude that the research effort was uniquely successful. Not only did all the teams attempt a very difficult and complicated exercise, but also all of the research groups assembled multi-disciplinary teams for the study and in all cases gained tremendously from the discussions, criticisms, and work of all of the different researchers participating in the study. The studies covered a wide area, and the industrial sectors/branches covered by the different research groups are shown in Table 1.

Although it would be impossible in this brief statement to summarize all of the studies, it would be of interest to sketch some of the more pertinent results. Almost as expected, the selection of studies confirmed certain common patterns of economic behaviour based on the technology, inputs, outputs, and market structures that cut across the countries in the textile sector — the area of study common to all groups. Similarly, the research from groups that have carried out studies on dissimilar industries also shows some patterns of behaviour common to each country, across the different industries, based on local skill compositions, and with respect to market structures and government policy.

Table 1. Areas of research of the various countries.

	Bangla-desh	Pakistan	Philip-pines	South Korea	Sri Lanka	India
Textile						
Fibre				X		X
Spinning	X	X	X		X	X
Weaving	X	X	X		X	X
Machinery manufacture						X
Pharmaceuticals		X				
Diesel engines				X		
Machinery				X		
Low-density polyethylene				X		
Glass					X	
Paper					X	
Cement					X	

The studies provide strong evidence to suggest that a certain element of technological learning and development of a capacity to achieve minor technological innovations almost invariably accompanies the creation of any industrial production capacity. They also demonstrate that whether the learning effects are strong or weak can depend on a large number of other factors. The studies tend to corroborate the statement that the degree of local planning and involvement in the production process from the earliest stages are critical to the process of improving local technological capacity: so also are deliberate policies to integrate the technology of production into the local economic and technological structures. In addition to these policy variables, the overall state of the economy, the structure of the market, and the rate of growth of domestic production seem to be important variables affecting the extent to which local capacity is created to operate efficiently, duplicate, and innovate upon the acquired techniques of production. In two of the cases from South Korea, the nylon and low-density polyethylene (LDPE) plants, the rates at which the technological capability were built up — as measured by plant efficiencies, increased outputs, and documented process improvements — were indeed phenomenal and serve to illustrate the factors that have contributed to the rapid learning curves exhibited. However, examples from other countries illustrate that the mere existence of production capacity or its creation are not sufficient to ensure the growth of technological capability. In fact, in some cases, it can be argued that negative learning can easily result from the combination of adverse policy and environmental factors.

Another conclusion that may be drawn from the studies is that industries or sectors that are widely dispersed in an economy and for which the market and production capacities are growing rapidly and steadily may not need the same measures of attention to promote local technological capability as those in which new capacity is added intermittently. This latter problem may be especially acute in smaller economies where a new plant of a given type may be needed only once every 5–10 years. In the latter case, a more focused and integrated set of policy instruments is essential to overcome almost certain failure of the market mechanism to induce the localization of relevant know-how and know-why.

Different types of policies with greater emphasis on the diffusion aspects may be more important for those production technologies catering to large market demands. The extent of variation between firms in their efficiency of resource utilization in a relatively old technology such as textiles underlines the importance of diffusion as a technology-related policy objective.

With regard to the methodological aspects of the research, a number of different approaches and measures were used in the studies to come to grips with and to quantify concepts such as technological capability. Use was made of local involvement in planning and design of production facilities, numbers of expatriate personnel, both over time and between plants, rate of efficiency of plant operation and its change over time, and minor and major innovations demonstrated by product and process innovations and patents. Although all of these measures were interesting and each was able to provide some useful insight, the most useful first approximation of technological capacity was the efficiency of resource utilization, which for comparative purposes can often be scaled to allow comparisons to be made among firms in the same economy or between countries for the same sector. Also, these could be analyzed for the nature and rate of change over time. In most cases, the notions of technological capability that could be derived with this measure correlated well with those

gleaned from the other measures. Efficiency was also a useful measure as it had a certain transferability from the firm to the sector and from the micro concerns to the macro.

Another fascinating area that was explored in some of the studies was the extent to which technical change is perceived, with justification, to have strong negative impacts on social and economic welfare. The thrust of technical change in almost all products and processes is for the more modern technique of production to require less labour per unit of output, with varying impacts on different skill groups, and to require more capital per unit of labour employed. The trend is of sufficient universal validity to raise serious doubts about the theoretical possibility of developing efficient and more labour-intensive technologies to produce standard goods.

The technological changes that replace labour by capital are, at the same time, often accompanied by process and product quality improvements of sufficient magnitude that even though, in labour-surplus economies, the earlier technique of production may be both socially and economically more efficient a price has to be paid in the loss of market demand. The loss of market is often most significant in export trade and thus results in a loss of foreign exchange. If the quality differences are significant, however, domestic markets can also be lost even under a protective policy due to smuggling or through the political expression of repressed demand. Under these circumstances, the policymaker faces the unenviable choice of using and promoting improved production technologies, thus raising productivity and quality but lowering employment, or protecting existing capability and employment, thus foregoing trade and possibly reducing prospects of future technological development.

Naturally, as with any set of studies, these generate as many new questions as they answer. For instance, in the reports from South Korea, one sees what can only be described as successful instances of generation of local technological capability and the absorption of foreign technology in the nylon and LDPE plants: in the cases of iron and steel and heavy machinery plants, however, the results obtained were more mixed. Clearly, we would like to know whether these contrasts were random or related to the technology of each case or to the ownership structure of the firms. Similarly, comparison of the Kolon Co. Ltd. in South Korea and synthetic yarn manufacture in India shows a complete contrast in terms of government policies. In the former case, a single large plant was favoured; in the other, a large number of smaller plants with different ownership was preferred. It would be illuminating to conduct a more detailed comparative study of these plants in the two countries to determine the advantages and disadvantages of the two strategies. Such examples can be multiplied manyfold.

To the extent that these studies not only provide some answers but also provide a framework for developing a set of useful research questions, and to the extent that these were generated by a group of researchers from the countries themselves through a unique series of discussions whose spirit is reflected in the comments on the papers, the exercise has been a valuable one.

Amitav Rath

Accumulation of Technological Capability and Assimilation of Imported Industrial Production Systems in the Cotton Textile Industry in Bangladesh

Quazi H. Ahmed[1]

For many years, concerns about the effects of technology transfer have concentrated heavily on the relatively short-run costs of transfer. These costs may be considered under the headings of direct and indirect costs (UNCTAD 1972). Direct costs include (1) payments made for importing capital goods; (2) payments made for technical services in preinvestment, investment, and operational phases; and (3) payments made for the right to use patents, licences, know-how, and trademarks. Indirect costs include (1) charges resulting from overpricing of imported intermediate products and equipment (hidden cost or price markups); (2) charges arising from profits on capitalization of know-how (equity participation in place of, or in addition to, other means of payments for the transfer of technology); and (3) charges in the form of some portion of repatriated profits of wholly owned subsidiaries or joint ventures, the establishment of which does not include specific provisions for payments for the transfer of technology.

There has also been concern about the effects of transferring technology in terms of the "appropriateness" of the production system transferred in light of the factor availability and other conditions of the importing economy. The concern has focused mainly on capital-intensive versus labour-intensive techniques.

The output from the technology transfer process is not only the physical components of technology (i.e., the production systems and machinery) but also the technical knowledge and skills relevant to the particular production system. A more recent concern about technology transfer has been to understand how, and to what extent, it contributes to the local accumulation of technical knowledge and skills, which constitute the technological capability of the importing society.

This study does not focus directly on the transfer and accumulation of knowledge and skills but instead on various aspects of techno-economic performance of the textile industry. The study suggests that there are "symptoms" that are likely to indicate the extent to which industry has accumulated relevant technological and techno-managerial capabilities. This, in turn, may indicate whether technical knowledge as well as technical systems have been acquired, absorbed, and diffused during the process of technology transfer. The question of whether or not there is evidence to suggest that the acquisition, absorption, and diffusion of technical knowledge is a matter of significant concern for the cotton textile industry in Bangladesh is investigated. By focusing on the extent to which the imported production systems have been effectively assimilated within the economy, an affirmative answer to this question has been reached.

The term "assimilation" is used to cover different aspects of techno-economic performance – aspects that reflect the extent to which the imported production systems have become viably rooted within the importing economy. The following aspects of performance (i.e., the symptoms of assimilation) will be discussed: (1) levels of efficiency in operating the production systems that are set up as a result of the technology transfer process; (2) rate of change in production efficiencies; (3) degree to which the techniques are structurally integrated within the economy

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with respect to current inputs for production (e.g., raw materials and spare parts) and with respect to inputs for investment in new mills and in capacity expansion of existing plants (e.g., machinery and equipment and investment-related technological and techno-managerial services); (4) extent to which endogenous processes of incremental technical change are developed locally in order to provide improved techniques for expansion of the industry; and (5) extent to which a technical change can draw upon a local process of more radical innovation to provide successive improved technical change.

(1) Production efficiencies are reflected in machine productivity, labour productivity, capacity utilization, and wastage rates expressed in physical units. If these efficiency indicators are up to the "standard," then it may be concluded that the imported system has been assimilated at least to some extent within the local environment. Standard levels of performance (e.g., output rate, wastage rate) are normally specified by the supplier of the production system. Manpower requirements to operate the system are also given by the supplier. It is possible, therefore, to compare the performance of the system with the specified standards. Alternatively, one can compare the performance with that of other countries that are using the same techniques of production and are (were) at a "similar stage in the development" of a particular industry as the economy under consideration. Any deviation from the standard level of performance will warrant some explanation.

(2) In a dynamic industrial economy, production techniques are not operated at static levels of efficiency. Even without investment in new techniques of production, it is possible to raise production efficiency continuously as a result of "learning" and incremental technical change. This phenomenon has been demonstrated in a number of empirical studies, both in developed and developing economies. Among these, Hollander's (1965) study of Dupont rayon plants and the study of Katz et al. (1978) of a rayon plant in Argentina are illuminating. In Hollander's study the contribution of ongoing technical change within existing plants was found to be overwhelmingly important for substantial cost reduction over time.

(3) Structural integration will be indicated by the extent to which the imported system draws on local rather than imported inputs, i.e., raw materials, spare parts, and intermediate goods. When a production system is imported in developing economies, large portions of these inputs are imported as well. As the system becomes structurally integrated within the economy, however, large portions of the imported inputs are produced locally and used successfully without lowering the efficiency of the system. The degree of success in this regard will depend upon the extent to which various kinds of technological capability are built up around the initially imported system. It will also depend on many other factors, e.g., the technological capability of other sectors that might provide these inputs and the types of programs offered by educational vocational training institutions. This process of integration is likely to be cumulative — the greater the structural integration achieved, the fewer the imported inputs required for the subsequent importation of similar production systems.

After the importation of a particular production system for the first time, it may be possible to learn sufficiently from the system to allow for the replication of the technique (partly or wholly) with the help of locally supplied goods and services for expansion of capacity. The case of "reverse engineering" followed by Japan (Cooper 1973) during their period of industrialization illustrates one way this can be achieved. It may also be possible to develop the capabilities to carry out locally, at least, some of the activities that are required to expand capacity and that were previously carried out by foreign personnel at the initial stage, e.g., feasibility studies, providing consulting services, developing specifications, designing the plant and its component elements, and producing capital goods. This is possible only when conscious efforts are made to reduce dependence upon foreign know-how and techniques.

(4) After a production system has been imported and installed, it may be possible not only to improve the efficiency of the system that was initially imported and to replicate that system for capacity expansion but also to develop improvements for incorporation into new plants. Such technical change may be considered "minor" or "major" (Hollander 1965). A minor technical change involves an "incremental" or "evolutionary" alteration in the existing techniques. A major change, on the other hand, involves a significant departure from the existing methods. Continuous efforts to bring about incremental technical change may result in a significant increase in efficiency. If such technical changes are effected with the help of endogenous resources, then the resultant improved technique and the accumulated capability may also be utilized effectively for the expansion of the industry. The ability to effect change will vary from economy to economy due to the variation in availability of skills, supporting services, leader-

ship quality, type of contractual agreement with the technology supplier, and a host of other reasons that are very specific to the economy under consideration.

(5) Major technical change involves a significant radical departure from existing methods and is, therefore, relatively difficult to accomplish (Hollander 1965). To accomplish major technical change, continuous support from research and development groups (both internal and external) may be essential. The degree to which support comes from local research and development and other related sectors to carry out major technical change is also an indication that substantially dynamic processes of local technological capability have been accumulated. The extent to which these different kinds of activities are carried out locally can be said to indicate the degree to which initially imported technical systems have been "assimilated" within the economy.

The degree of assimilation that is effected will depend upon many factors. This study focuses on the fact that it will, in part, be a function of the level and composition of local technological capabilities. In turn, the levels and compositions of local capabilities that are accumulated will depend on various factors. Firstly, they may result from local efforts to accumulate technical knowledge and skills. Secondly, they will depend upon the acquisition and absorption of technical knowledge and skills from the technology transfer process. The optimum combination of these two efforts may lead to desired levels and structures of capability accumulation and, hence, toward desired degrees and patterns of assimilation of the imported technology. Thus, the so-called technology transfer process may provide two outputs for the technology importer. Firstly, it will usually provide a particular production system (i.e., a textile mill or part of one) that may or may not, subsequently, be assimilated in the various ways mentioned earlier. Secondly, the transfer process may provide an output of technical knowledge, skill, and experience. The extent to which the technical system is assimilated will depend, in large part, on the extent to which knowledge and skill are acquired by and absorbed within the local economy.

In light of the indicators of assimilation mentioned earlier and the actual performance of the textile industry in Bangladesh, it appears that the imported technical systems have been poorly assimilated, which suggests that there has been very limited accumulation of local technological capability. In view of this, it is suggested that the way in which local technological capability is accumulated and, more specifically, the role that is played by the technology transfer process should be examined in detail in subsequent work.

Only the levels of production efficiency, the rate of change of production efficiencies, and the degree to which the techniques are structurally integrated within the economy will be discussed here. By limiting the study to these three aspects there are some comparable data, particularly the levels and trends of production efficiencies, available from published sources from industrially developed countries that allow some direct comparisons of levels and trends of performances to be made.

Historical Background of the Textile Industry

The cotton textile industry in Bangladesh is an import-substitution industry. At the time of independence of Pakistan and India, in 1947, Bangladesh (formerly East Pakistan) had only 10 cotton textile mills, with an installed capacity of 109 740 spindles and 2717 looms. This installed capacity was increased to 750 000 spindles and 7000 looms in 1969–1970 and 982 000 spindles and 8000 looms in 1977–1978 (spread over 48 mills). Growth of this sector up to 1970 (i.e., during the Pakistan regime) took place in the private sector. However, after the liberation of Bangladesh (i.e., after December 1971), the running as well as the development of the industry has been the responsibility of the Government of Bangladesh. Easy credit, cheaper imports of capital goods (due to overvalued local currency), a protected market, and the potential for high profit were the attractions for the private investors in the cotton textile sector during the period up to 1970.

Development and expansion of the cotton textile industry in Bangladesh took place through the importation of machinery, mainly from Japan and the United Kingdom. A small portion of the machinery was, however, supplied from within Bangladesh. In addition to capital goods, investment-related services (i.e., services for the selection, installation, and commissioning of machinery) were also imported. Local engineers and technicians have now acquired these skills and the importation of such services has virtually been eliminated.

Prior to 1971, raw cotton used to be bought from West Pakistan (a domestic source of supply), but after the break with Pakistan it was imported from different countries throughout the world. Most spare parts were also imported. Textile mills in Bangladesh lost a large number of non-Bengali managers and technicians during

and immediately after the War of Liberation of Bangladesh. This created a short-term vacuum of techno-managerial skills within the industry.

Based on the target (set by the government) of 12 yards (11 m) per capita availability of cloth, the Bangladesh Textile Mills Corporation will be required to set up a total of 39 spinning mills of 25 000 spindles each by 1985. This will cost approximately Tk4524 million (U.S.$262 million) in total, of which about Tk1397 million (U.S.$81 million) will be required in foreign exchange. In addition to this huge amount of money, the Bangladesh Textile Mills Corporation will also be required to train and develop (or import) technical and managerial manpower to run these units efficiently within a short period of time. Therefore, both the history of the industry and the likely future expansion present considerable problems for the technology policymakers in relation to the sector.

Levels and Trends of Indicators of Aggregate Industrial Performance

Analysis of the performance of the industry as a whole showed a general downward trend over time. Machine productivity, labour productivity, and capacity utilization were used as the efficiency indicators for this analysis. Values of these indicators are shown in Table 1.

The fluctuation of spindle productivity from 1961 1962 to 1976 1977 was not statistically significant. On the other hand, the decline of loom productivity during the same period was found to be significant at the 1% level ($t = 5.25$, $r^2 = 0.70$). The decline of capacity utilization based on installed spindles was found to be significant at the 5% level for the period 1960 1961 to 1977 1978 ($t = 2.26$, $r^2 = 0.29$), whereas it was not significant on the basis of installed looms. However, the decline of capacity utilization from 1960 1961 to 1969 1970, based on installed looms, was found to be significant at the 1% level ($t = 3.52$, $r^2 = 0.64$).

International Comparison

The performance of the Bangladesh textile industry was also compared with the textile industries of Japan, the United Kingdom, and the USA on a limited scale. On the basis of spindle productivity, labour productivity, and proportion of running to installed equipment (i.e., spindles and looms), the performance of the Bangladesh textile industry was found to be lower than the performance of the textile industries in these three countries, e.g., Fig. 1 compares the spindle productivity between the United Kingdom and Bangladesh.

Structural Integration between Textile Production and Other Forms of Production

Very little integration of imported textile production systems with other forms of production (e.g., spare parts, accessories) in the economy of Bangladesh has been observed. Backward

Table 1. Trends of the indicators of aggregate industrial performance.

Year	Machine productivity (index)				Labour productivity (index)		Capacity utilization (percentage)			
							Spinning		Weaving	
	Spindle		Loom		Spindle		Installed	Operating	Installed	Operating
1960 61							58	59	93	93
1961 62	100		100				59	62	90	90
1962 63	102		87				49	60	74	74
1963 64	105		75				54	62	48	48
1964 65	89		75				46	50	39	39
1965 66	101		78		100		50	57	27	53
1966 67	98		86		76		50	60	31	55
1967 68	103		75		74		52	61	30	52
1968 69	107		69		86		58	66	35	61
1969 70	117	100	76	100	108	100	63	71	34	79
1972 73	78	67	36	53	53	49	42	57	33	58
1973 74	95	81	61	91	52	48	47	60	45	64
1974 75	99	84	57	85	56	52	50	60	48	68
1975 76	95	81	58	87			48	58	42	60
1976 77	94	80	55	82			44	48	45	68
1977 78							41	50	41	66

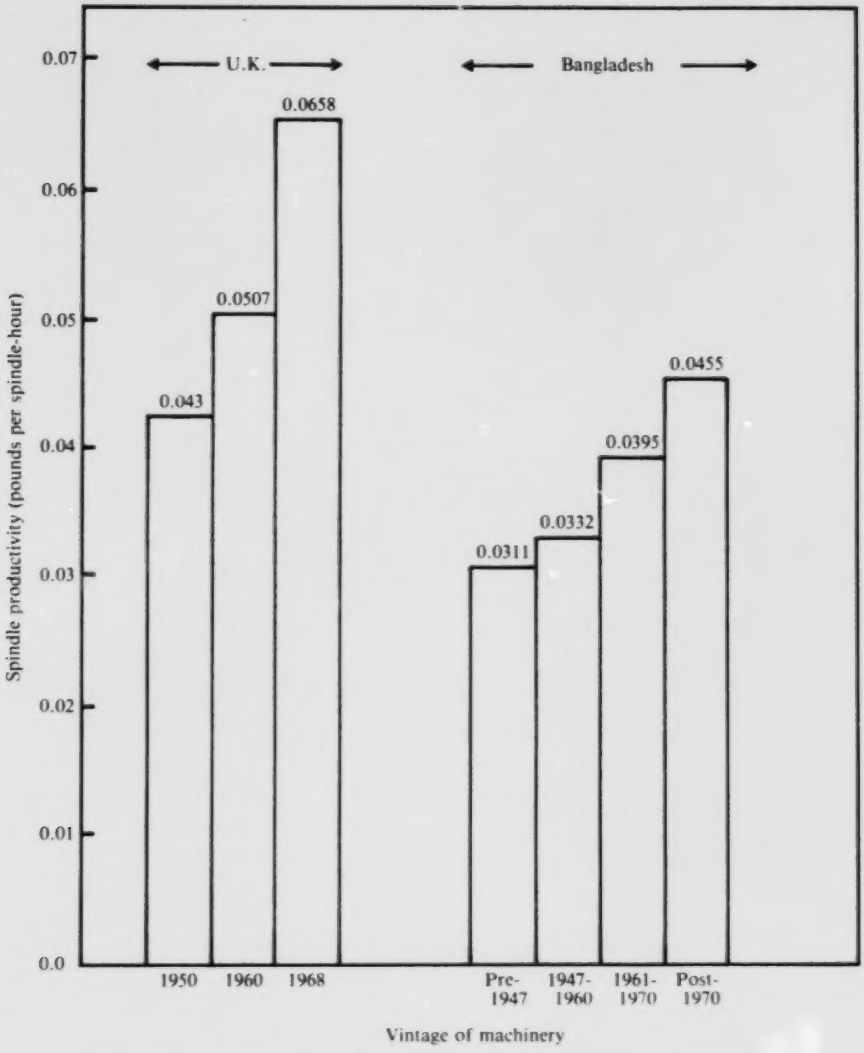

Fig. 1. Intervintage comparison of productivity (20 count yarn).

linkages with the capital goods manufacturing sector have been very unsatisfactory. Services related to the erection and commissioning of textile machinery are, however, available from within the economy.

Plant Level Analysis

The above findings on the performance of the industry led to the conclusion that imported cotton textile manufacturing technology has been poorly assimilated in Bangladesh. A detailed analysis was carried out to identify the reasons for such a poor performance of the Bangladesh textile industry. The performance data from 12 sample mills were analyzed. Three independent variables (age, size, and machine heterogeneity) were identified to explain the variations of the performance indicators in different mills. Machine productivity, labour

productivity, wastage rate, and the proportion of idle to installed equipment were used as measures of performance. Both statistical and nonstatistical tests were carried out to examine the relationships between the independent variables and the measures of performance. In general, no strong relationships (except in one case) between the independent variables and measures of performance were observed. However, weak relationships between the vintage of equipment and spindle productivity and idleness of spindles, a weak relationship between machine heterogeneity and spindle productivity, and a strong relationship between size and proportion of idle to installed looms were found. These results are summarized in Table 2.

Analysis of the average performance of groups of mills having different (average) heterogeneity revealed that the performance of the less heterogeneous groups was significantly lower than that of the more heterogeneous groups.

From the stepwise multiple regression analysis it was found that all three independent variables (age, size, and heterogeneity) combined explained 93% of the variations of the proportion of idle to installed looms at the 0.8% level. Variations of the other dependent variables (i.e., spindle productivity, loom productivity, and proportion of idle to installed spindles) were not found to be significantly influenced by these independent variables.

The two "best" and two "worst" performing mills in each of the spinning and weaving operations were identified based on the composite index of performance (computed for this purpose). The three above-mentioned independent variables were not able to explain the performance pattern of these best worst mills.

Techno-Managerial Capability and Assimilation of Imported Industrial Technology

Having found that the three independent variables were unable to explain the performance pattern of the mills, a fourth type of explanation was examined, i.e., the intermill variation of performance is probably due to the differences in quality of available techno-managerial knowledge and skills. A brief discussion, on a general level, of the possible influence of the availability of the right type of technical and managerial skills (both inside and outside the mills) on the performance of the mills revealed the significance of this fourth explanation. A preliminary description relating the extent to which technological and managerial capability had been accumulated within Bangladesh was looked at. Only three aspects were examined: (1) the extent and nature of local efforts to accumulate and diffuse technical knowledge and skills, (2) the extent to which technical knowledge and skills were acquired and absorbed through the process of technology transfer, and (3) evidence of the accumulation of the capability to effect change.

The only significant local effort to accumulate and diffuse technical knowledge was found to be in the activities of the College of Textile Technology. Because the technical and managerial training programs of the Bangladesh Textile Mills Corporation headquarters have just been geared up, a definite comment on the effectiveness of the programs could not be offered.

With respect to the absorption and diffusion of technical knowledge and skills from the technology transfer process, it was found that some degree of accumulation of technical knowledge and skills has taken place, e.g., local technical people are capable of providing services related to the investment phase, manufacturing some of the spare parts, and duplicating simple machinery (e.g., reeling machines). In addition, some fragmentary evidence indicating dynamic technical change has been found, e.g., changing of the lift size of the spindles and increasing the speed of warping machines to increase productivity.

Table 2. Summary results of statistical analysis

Variable pairs	Correlation coefficient (r)	Coefficient of determination (r^2)	Level of significance (%)
Age of machine and spindle productivity	0.6842	0.468	1.5
Age and proportion of idle to installed spindles	0.6981	0.487	5.4
Heterogeneity of machine and spindle productivity	0.6714	0.457	5.7
Size and proportion of idle to installed looms	0.8714	0.759	0.5

Conclusions

From this preliminary investigation it has been found that imported cotton textile technology has been poorly assimilated in Bangladesh. The extent and nature of technological and managerial capability accumulation seems to have been inadequate with respect to both local efforts and acquisition from the technology transfer process. This has probably been a major reason for the unsatisfactory degree of assimilation.

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Comments: Ashok Desai

Levels of technological performance or capability can be judged with respect to differing degrees of competence in: (1) operating a plant, (2) duplicating or expanding a plant, (3) transferring a technology, and (4) innovation.

The comments that follow are based upon material in the comprehensive Bangladesh report, the numbers in parentheses indicating the appropriate page number in that report.

(29) Table 2.4 — The count composition of the output changed radically toward coarse counts in the 1960s. What is the explanation? Exports to India are unlikely to explain the change.

(39) Spindle productivity increased in the 1960s. This may be related to the falling average count of yarn.

(45) The fall in labour productivity after liberation was clearly due to the large increase in the labour force. In fact, the most interesting questions to ask are: How did the enterprises adjust themselves to the overstaffing? How did they maintain output? What did the new workers do? How was work shared? What did the overstaffing do to management control?

(47) The figures of standard machine output are too modest.

	Spindles (lb)	*Looms (yards)*
Bangladesh standard	*75*	*10000*
Indian average	*110*	*28000*

Even mills in Bangladesh were producing 23 000 yards/year/loom (21 031 m/year/loom) in the early 1960s.

(50) Something odd is happening in weaving. Output per operational loom declined from 23 000 yards (21 031 m) in 1960–1961 to 10 000 yards (9144 m) in 1964–1965, rose again to 20 000 yards (18 288 m) in 1969–1970, and was not much lower in the 1970s. The proportion of installed looms in operation, however, fell enormously. Why, then, were the new looms installed? Why did mills buy them while they had idle looms?

(79) In contrast to looms, where the operational looms' average output was steady but there was a large proportion of idle looms, spindle capacity utilization was fairly high but the productivity per operating spindle was low. Why was it low?

(117) It is futile to look for economies of scale in spindle or loom output, for there are none. A large mill has an advantage in upstream operations — blowroom, cotton blending, carding — and downstream operations — finishing and dyeing.

(123) Does the correlation of age and spindle productivity refer to operating spindles or total? It would be better to correlate separately the proportion of operating looms and spindle productivity. Primary comparisons between mills are hazardous because the influence of non-technological factors is unlikely to be cancelled or averaged out.

(153) In the correlation of length of spindle and productivity, the regression coefficient would be more interesting than the correlation coefficient. In general, multiple regressions are more informative than stepwise simple regressions, and full regression estimates should be given.

(154) Automatic looms, at least the earlier models, were no faster than plain looms; their output per shift could not be expected to be higher. Labour productivity with automatic looms, however, should have been higher than with plain looms.

It seems that Bangladesh would provide valuable case material by answering the question: How is a technology adapted to a sudden increase in overstaffing?

Absorption and Diffusion of Imported Technology: A Case Study of Four Industries in Sri Lanka

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Industrial Development in Sri Lanka: A Brief Outline

Since the early 1930s, when the elected representatives of the people had a voice in the government of the country, the demand for industrialization has occupied a prominent place in the programs of the major political parties. The prevailing poverty and backwardness of Sri Lanka have been attributed to its colonial status as a supplier of cheap raw materials and agricultural produce to Britain and a captive market for manufactured goods from industrialized countries. Agitation for industrial development to reverse this trend and achieve balanced economic growth, thereby raising the standard of living of the people gained ground throughout the 1930s.

With the outbreak of World War II, Sri Lanka was cut off from its traditional sources of supply. In order to meet the widespread scarcity of all types of manufactured goods, a number of manufacturing units were set up. These included factories for the manufacture of plywood, rolled steel, cardboard, drugs and pharmaceuticals, acetic acid, glassware, etc. All of these units were small scale, with improvised machinery and a primitive level of technology that had been developed within the country or borrowed and adapted from neighbouring India. One of their salient features, however, was self-reliance.

The quality of the products from these local units was, understandably, poor and the prices relatively high in comparison with imported articles. In spite of this, however, there was a ready market due to the prevailing scarcity of goods. This wartime scarcity of manufactured goods and the success of the local ventures, hastily set up to meet this scarcity, gave an added impetus to the demand for industrialization. Plans, therefore, were prepared in earnest for setting up a number of large-scale industries after the war. In this regard, the government's postwar development plan, published in 1946, identified no less than 26 industrial projects for establishment.

Immediately after the war, a program for modernization and expansion of the wartime ventures and the establishment of a few large-scale units was initiated. The first generation of new industries that came into existence — all of them in the public sector — included a cement plant, pulp and paper mill, vegetable oil factory, caustic soda and chlorine plant, and plywood factory. Unlike earlier, when the small-scale wartime units were set up largely with local know-how, the establishment of the postwar large-scale units depended entirely upon foreign expertise, from the feasibility stages through to the operation of the factories. All plant and machinery and structural steel for buildings and structures were also imported.

By the early 1950s, substantial progress had been made in the implementation of the industrialization program. The cement factory was the first to go into production, while the other industries were at various stages of construction. In addition, feasibility studies for steel, textile, and fertilizer manufacture were under preparation. Meanwhile, there was another development that had an adverse affect on this program. After the war ended, all types of imported manufactured goods became freely available in Sri Lanka again and the products of the local wartime factories could not compete with these imports. Consequently, the government was compelled to adopt various protective measures, such as import controls, to give relief to local industry. This, in turn, prompted the powerful

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import lobby to mount a campaign against local industries. The arguments advanced during this campaign were that Sri Lanka had no comparative advantage in the manufacturing industry; the local market was very limited and could be met by a few days' or weeks' output from most modern manufacturing units in industrialized countries; and for the successful establishment of industrial enterprises, substantial capital investment and sophisticated technical and managerial skills — all very scarce in Sri Lanka — were needed.

It was also asserted that it was not the legitimate function of government to engage directly in manufacturing or commercial activities. To reinforce these arguments, various shortcomings in the public sector enterprises were frequently spotlighted in the press and in parliament. As a result, public opinion prejudicial to state ventures was gaining ground daily. It is against this background that one has to view the recommendations of the World Bank Mission, which was in Sri Lanka in 1952 to study and report on the economic development program.

The World Bank Mission, in its report, emphasized the need for the development of agricultural and infrastructural facilities. The mission strongly urged the government to leave commercial and industrial ventures in the hands of the private sector and, as far as industries were concerned, they favoured only small- and medium-scale units. With regard to the industrial projects already under construction or at various stages of planning, the mission recommended the virtual abandonment of almost all of the units except the cement factory, which had already been completed. The government, acting on the mission's report, promptly froze all of the funds for the pulp and paper, ceramics, oils and fats, and chemicals projects, on which work was in progress, and abandoned the steel project, on which work had just been initiated. After a reappraisal of the projects, however, work was resumed on all of the projects except steel.

The government at that time was fully committed to private enterprise and was not in favour of state industrial and commercial ventures. The local private sector, however, had neither the capacity nor the willingness to risk their capital in industry and the government, therefore, came to the conclusion that the key to the future of industrialization in Sri Lanka (particularly large-scale industry) lay in the hands of foreign capital investors and in order to attract foreign capital various attractive inducements were offered. At the same time, in order to ensure the efficiency of public sector enterprises, it was decided to hand over their management to autonomous corporations and at a later date sell shares in the enterprises to the public. What was envisaged at that time was that eventually the ownership of viable units would pass into private hands.

There was a major shift in the industrial policy of Sri Lanka when a government, pledged to a radical program of work and a strong bias in favour of the public sector, was swept into power in 1956. In industry, the importance of heavy and basic industries to the economy was emphasized and pride of place assigned to the public sector. As there had been very little response from private capital investors (both local and foreign), in spite of the attractive inducements offered by the previous government to invest in industry, the new government was forced to look elsewhere for assistance in implementing its policy on industrialization. The government found an ally in the USSR, with whom Sri Lanka had just established diplomatic relations. Negotiations on economic cooperation between the two countries, finalized in 1958, identified 17 projects, for which the USSR agreed to provide the necessary technical expertise and plant and machinery. Amongst the projects identified and implemented in the industrial field were a steel rolling mill, an automobile tire and tube plant, and a flour mill. These were all relatively large-scale projects and took several years to complete.

The role of the Soviet organizations in the implementation of these projects consisted of carrying out preliminary surveys and investigations; preparing designs; supplying plant and machinery and construction materials; and assisting in the construction and initial operation of the plants and in the training of local personnel, both at similar plants in the USSR and on the job in Sri Lanka. For all supplies and services from the USSR, a long-term loan with very generous repayment terms was granted.

Three noteworthy features from the point of view of technology transfer distinguish this technical assistance program from earlier experiences with project implementation in Sri Lanka. Firstly, at every stage, from preliminary surveys of the local market and raw materials through to the construction and operation of the plants, local counterparts were associated with Soviet specialists and decisions were arrived at, as far as practicable, on the basis of joint discussions. During the construction and initial operational stages, the Soviet specialists always insisted that their local counterparts be responsible for decision-making and they (the Soviet specialists) remained in the background, to step in if things went wrong. This arrangement helped build local expertise, in marked contrast to earlier experiences with foreign consultants and specialists.

Secondly, complete and comprehensive documentation of all aspects of the projects was furnished to enable the local organizations, if needed, to fabricate certain components and spare parts on their own. Training of local personnel in Soviet factories was also very thorough. The trainees were not given a "Cooks tour" as often happens when trainees are sent to developed countries, but were given a comprehensive course combining both practical and theoretical training and were subjected to a final test at the end of the training period.

Thirdly, prior to this technical assistance program from the USSR, foreign consultants had been responsible for the civil engineering design of industrial buildings and structures and their construction, particularly in the case of large-scale units entrusted to private foreign contractors. At the suggestion of the Soviet Aid Agency, however, a public sector enterprise was established to undertake the design and construction of buildings and structures for industrial projects in Sri Lanka, commencing with the first three Soviet-aid projects. With the experience gained in these projects, this particular organization subsequently developed sufficient capability to undertake detailed civil engineering designs as well as construction of several major industrial projects.

Industrialization continued throughout the 1960s and 1970s, large-scale industries being confined mostly to the public sector with bilateral aid, notably from the Federal Republic of Germany for the expansion of the cement and paper industries and from the German Democratic Republic and the People's Republic of China for textile industries. The import substitution program inaugurated in the early 1960s and the export promotion drive, which began toward the end of that decade, stimulated the private sector and led to the establishment of a large number of small- and medium-scale consumer goods and service industries.

The 20-year period from 1956 1976 was marked by a steady growth of industries in Sri Lanka. These industries covered a wide range of products including basic and essential goods to the economy, such as cement; rolled steel; refined petroleum products; paper; plywood; agricultural implements, tools, and chemicals (caustic soda and chlorine); and consumer goods, such as textiles, ceramics, glassware, ready-made garments, footwear, plastic goods, and food preserves. Most large-scale industries were in the public sector, with the exception of a few textile mills in private hands; whereas almost all consumer goods industries, with the exception of ceramics and textiles, were privately owned.

In the course of construction and operation of the numerous factories and workshops during the past 20 25 years, there came into existence a wide range of technical and managerial skills and considerable interaction between educational, training, and research institutions in the country. As a result of this generation of skill and expertise, by 1975, Sri Lanka was in a favourable position to undertake, on its own, with only marginal assistance from abroad, the design, construction, and operation of industrial enterprises involving, in some cases, sophisticated technologies. The absence of a capital goods sector, however, was no doubt a drawback in what was otherwise a major stride toward self-reliant growth.

This commendable achievement also had its own drawbacks, which, in turn, tended to inhibit further development of this growth process. Lack of competition due to a virtual ban on the import of all manufactured goods and strict licencing of industrial units; granting of complete monopoly to state corporations for a number of products such as cement, paper, and steel (not only for production but also for import and distribution); and strict enforcement of quotas for the import of raw materials, spare parts, etc., led to low levels of capacity utilization, lack of competition, poor-quality products, and the high cost of manufactured goods. The whole economy was restrictive and inward looking.

A major shift in policy occurred when a new government, with an unprecedented majority, assumed office in mid-1977. More reliance was placed on market forces than on the planning process to achieve the goal of economic development. Although the public sector still continued to dominate the industrial landscape, growth was now more marked in the private sector due to positive encouragement and a wide variety of incentives provided for both local and foreign entrepreneurs, including the establishment of free trade zones. All controls, virtually, were dismantled and local manufacturers had to compete with unrestricted imports. The full impact of the new policies is still to be assessed.

Summary of Industries

Pulp and Paper

The manufacture of pulp and paper in Sri Lanka is presently the exclusive monopoly of the state-owned National Paper Corporation (NPC), which currently operates two pulp and paper mills, one in the eastern part of Sri Lanka and the other in the south. Both mills are fully mechanized and equipped with modern machinery for

Table 1. Growth of the National Paper Corporation.

Period	Average annual imports (tons)	Average annual production (tons)	Average annual demand[a] (tons)	NPC's share of local paper market (%)
1950 54	21000	0	21000	0
1955 59	21000	1000	22000	5
1960 64	26000	5000	31000	16
1965 69	30000	9000	39000	23
1970 74	22000	14000	36000	39
1975 78	17000	20000	37000	54

[a]Demand is computed as the sum of imports and local production.

producing pulp from rice straw and manufacturing paper and paper boards utilizing straw pulp as the principal raw material, supplemented with imported long-fibre pulp.[2]

A feasibility study for a pulp and paper mill with a daily capacity of 12.5 tons[3] of paper was prepared in 1947, construction began in the early 1950s, and the mill went into production in 1957. Rice-straw pulp was the principal raw material and the output of the mill was confined to writing and printing paper. The capacity of this mill was increased to 35 tons per day in the mid-1960s, through modifications to the paper machine and the addition of balancing equipment, all involving a marginal investment. This was followed by the installation of a second paper machine and the necessary pulping facilities and auxiliary services in the early 1970s, thus increasing the total capacity of the mill to 75 tons per day. The output of the new paper machine included both printing and writing paper and paper boards.

A second pulp and paper mill, at a site in the southern part of Sri Lanka, with a daily capacity of 50 tons, and whose construction began in 1972, came into production in 1978. This mill was also designed to utilize rice-straw pulp as the principal raw material to produce printing and writing paper.

Over the years, the NPC's share of the local paper market gradually increased from approximately 5% in the 1950s to about 54% in the 1970s, as indicated in Table 1. Imports, at present, are confined largely to those grades of paper and paper boards that are outside the product range of NPC machinery.

The NPC has been dependent throughout on foreign consultants for the preparation of feasibility reports and for engineering services. All of the plant and machinery needed for the mills were imported and expatriate personnel employed for the installation of machinery and its testing, commissioning, and initial operation. During the second half of the 1940s, when the paper project was first considered, there was practically no one in Sri Lanka with any knowledge of or experience in the pulp and paper industry. Since then, through the establishment and operation of the paper mills, a large group of engineers, technologists and skilled workers, and managerial and administrative personnel have developed, numbering over 3000, who have eliminated the need to import foreign technology for new mills or expansion programs.

In the absence of a capital goods sector in Sri Lanka, there is little prospect of local manufacture of plant and machinery for pulp and paper or other industries. However, both in the repair workshops attached to the mills and in the engineering workshops in the country, about 50% of the spare parts required for the mills are fabricated.

Pulp from rice straw, due to its short fibre length, needs to be blended with approximately 35% long-fibre pulp, which is imported. Attempts to meet the entire needs for long-fibre pulp from indigenous sources have so far been only partially successful.

In addition to pulp, relatively large tonnages of other production supplies needed for making paper were all imported during the early stages. Over the years, the demand for these materials from pulp and paper and other industries has led to the establishment of plants for local manufacture of these items. The quantities of such major supplies required annually by the NPC and the extent of local substitution is tabulated in Table 2.

Cement

The manufacture of cement in Sri Lanka is presently the exclusive monopoly of the state-

[2]In addition to the NPC's two mills, there are a few small-scale paper-making units employing a low level of technology. Production from these units is confined to a few hundred tons of paper boards. Several paper-converting units manufacturing envelopes, paper bags, and cartons are also in existence.

[3]Refers to long tons throughout.

Table 2. Supplies required for pulp and paper production.

Material	Annual requirements (tons)	Percentage of local supply
Caustic soda	7000	25
Chlorine	1800	100
Kaolin	2250	100
Starch	260	80
Calcium hydrate	4000	100
Soda ash	2600	0
Alum	3400	0
Sodium sulphate	200	0
Rosin	1100	0

owned Ceylon Cement Corporation (CCC), which currently operates two cement plants: one on the peninsula in the north and the other about 80 mi (129 km) north of Colombo, and a clinker grinding plant about 75 mi (121 km) south of Colombo.

Investigations into the establishment of a cement industry in Sri Lanka began in 1945 and the first cement plant, on the peninsula in the north, with a rated capacity of 100 000 tons per annum, went into production in 1950. In the mid-1960s, this plant was modernized and expanded to 270 000 tons per annum. Part of the clinker output from this plant was transferred to a clinker grinding plant with a capacity of 100 000 tons per annum constructed around this period to feed the market in the south-western part of Sri Lanka. Construction on the second cement plant, with a capacity of 440 000 tons per annum, began in the late 1960s, and it was commissioned in the early 1970s.

Both cement plants utilize the dry process for cement manufacture; incorporate modern, sophisticated machinery; and are dependent upon indigenous limestone and clay and imported gypsum and fuel oils.

During the 1950s, when only the first cement plant was in operation, only slightly less than one-third of Sri Lanka's requirements for cement could be met. Once the expansion of the first plant was completed, the CCC's share of the market increased to about 68% and, by 1973, with the commissioning of the second plant, Sri Lanka became self-sufficient in cement, and even had an exportable surplus (Table 3). This situation underwent a major change when a large-scale construction program was inaugurated in 1978. Even near-capacity levels of production could not meet this increased demand and imports became necessary in 1979 and 1980. Due to the increasing gap between production and demand since 1978 and the potential for export, a major expansion program has recently been initiated.

The Ceylon Cement Corporation was entirely dependent upon foreign consultants for feasibility studies and engineering services for the establishment of the first cement plant. Although this dependence continued throughout expansion and new mill projects, there was a progressive increase in local participation in these activities, and in the expansion program now under way foreign participation is minimal. All plant and machinery were imported throughout this period and expatriate personnel engaged for machinery installation, testing, commissioning, and initial operation. As with the pulp and paper industry, the establishment and operation of cement plants resulted in the development of a large group of engineers, technologists and skilled workers, and managerial and administrative personnel, numbering over 2000, capable of future expansion or building new mills without relying on the import of foreign technology.

Unfortunately, the absence of a capital goods sector in Sri Lanka meant that plant and machinery for cement mills could not be manufactured locally. The CCC, however, is now planning to fabricate, at its own workshops and at outside engineering workshops, a sizeable volume of simple components and structures, which may amount to about 30% of the total volume of the machinery package required for the expansion program currently under way. At the same time, nearly 50% of the spare parts required will be fabricated locally.

Table 3. Growth of the Ceylon Cement Corporation.

Period	Average annual imports (tons)	Average annual production (tons)	Average annual demand[a] (tons)	CCC's share of local cement market (%)
1952 56	129354	72988	202342	36
1957 61	178250	76982	255232	30
1962 66	225207	78424	303631	26
1967 71	131169	276220	407389	68
1972 76	0	413848	413848	100

[a]Demand is computed as the sum of imports and local production.

Glass

The glass industry in Sri Lanka, entirely privately owned, is comprised of a single large-scale producer that manufactures bottles and nearly 20 small-scale units that produce domestic utility glassware such as tumblers, kerosene lamp chimneys, etc. Unlike the cement or paper industries, there is no monopoly in the manufacture of glass.

The first glass factory, established during World War II, came into production in 1943. This was a private sector medium-scale unit manufacturing utility glassware, with an output of about 1 ton per day. A short time later, a similar unit was set up in the public sector. When imports became freely available after the war, both units, in the absence of any protection and unable to withstand competition, were forced to close down. Thereafter, the Ceylon Glass Company, a private-sector enterprise with Japanese collaboration, took over the assets of the state-owned glass factory and implemented a program of modernization and expansion, raising its capacity to 15 tons per day. This factory came into production in 1957. Its capacity increased to 20 tons per day in 1961 and to 40 tons per day in 1963. Later, a second plant was built by the same company at a site closer to Colombo. The entire output of this company is confined to glass bottles. Both units are mechanized and are equipped to cover the entire process of glass-making, utilizing locally available silica and quartz.

In addition to the Ceylon Glass Company, which is the leader in the industry, there are about 20 private-sector units engaged in the manufacture of glassware. These units are all small scale, with practically no mechanization, and they utilize broken glass as their raw material. This, together with the low level of technology employed, has resulted in a poor quality product. All of these units, however, which came into existence in the 1960s and early 1970s, prospered because of the sheltered market. With increasing fuel prices and relaxation of imports since 1977, however, only a handful of these units are now surviving.

Almost the entire local requirement for glass bottles and containers and about 85% of utility glassware was produced locally until 1977, when imports were liberalized. In the absence of local manufacture, all plate and sheet glass was imported. An indication of the relative proportion of imports and local production and the sudden spurt in imports after liberalization in 1977 is given in Table 4.

Table 4. Proportion of local and imported glass products.

	Local production (thousand tons)				
Year	Bottles and containers	Mirrors	Others	Total	Imports
1977	18.203	3.313	3.986	25.502	17.176
1978	15.710	1.905	3.990	21.605	64.135

The first glass factory, established in the private sector in the early 1940s, obtained the necessary technical know-how and plant and machinery from an Indian firm. Operators from the same firm trained local personnel. The same procedure was also followed by the public sector unit that came into existence later. The expansion and modernization of the Government Glass Factory, taken over by the Ceylon Glass Company in the mid-1950s, depended to a large extent on expertise from its Japanese collaborator, both in terms of technical know-how and plant and machinery. This dependence on foreign technology was progressively reduced over the years through the various expansion programs of the company.

Dependence upon foreign technology varied in the case of the numerous small-scale units that came into existence in the late 1960s and early 1970s. In some instances the entire package — plant and machinery, foreign experts, and capital — came as part of a collaboration agreement. In other cases, former employees of the Ceylon Glass Company provided the necessary technical know-how and all requirements for plant and machinery were met locally — an indication of effective diffusion and assimilation of technology.

The total number of people employed in all of the units of the glass industry in 1979 was estimated to be about 1000. This included a few engineers and technologists and an adequate number of trained and experienced skilled workers.

Synthetic Textiles

With the exception of a single large-scale cotton textile mill, established in the private sector about 100 years ago, the manufacture of textiles in Sri Lanka until the 1950s was negligible and confined to a few handlooms. In spite of the substantial assistance provided by the government to the handloom sector in the 1940s and early 1950s, there was no appreciable increase in production, nor was there any private-sector initiative to undertake the manufacture of cotton textiles. This prompted the government,

in the latter part of the 1950s, to embark upon a major program of establishing a number of large-scale textile mills and decentralized powerloom projects, all in the public sector but confined to cotton textiles. Assistance to the handloom sector also continued without interruption. The manufacture of synthetic textiles was reserved for the private sector.

As a result of the government's initiative in the textile industry, there was a major increase in the number of looms installed, from 794 at the end of 1957 to 8029 by the end of 1977. Domestic production of textiles, which was approximately 1.54×10^7 yards (1.41×10^7 m) in 1957, increased to 1.164×10^8 yards (1.064×10^8 m) in 1977, and the share of domestic production in the local market registered a corresponding increase from 11.7 57.6% during this period.

With the drastic curtailment of imports after 1960, there was a ready market for both cotton and synthetic textiles in Sri Lanka. Although the manufacture of cotton textiles was reserved for the public sector, there was a profitable investment opportunity for the private sector in the synthetic textile industry. A ready market and liberal incentives for investment in the industry provided the impetus for a number of local entrepreneurs to establish synthetic textile mills. One such entrepreneur was already in the cotton textile manufacturing business. Four others, who were also pioneers in this field, were engaged in various trading activities: two of them in the textile trade itself.

The first five synthetic textile mills established in the early 1960s were large-scale units with facilities for printing and finishing. They were dependent upon imported technology for their establishment and operation. The package of imports was not uniform; it varied from a virtual turnkey project to a carefully selected list of items. Machinery in all cases was imported and with it a certain number of expatriate technical and managerial personnel. A number of these units recruited some of their skilled workers and most of their supervisory and managerial personnel from public sector cotton textile mills.

The success of the pioneering units attracted other investors and there was rapid growth in the synthetic textile manufacturing industry. Altogether, 10 synthetic textile mills came into existence between 1961 and 1965. Thirteen more mills were established during the next 5 years and two others since that time. Synthetic textile production, which was about 1.4×10^7 yards (1.28×10^7 m) in 1972, increased to about 2.0×10^7 yards (1.83×10^7 m) by 1978, which is approximately 16% of the total textile production and about 10% of the share of the total market.

The synthetic textile industry continues to be dominated by five large firms, which account for nearly 70% of the total output. Three of them are joint ventures with Japanese participation and two others with Indian participation. All other firms are locally owned. With the exception of two government-acquired undertakings (from the private sector) all other synthetic textile mills are privately owned.

The total work force employed in the synthetic textile industry is estimated to be about 5000. Over the years, there has been a great deal of diffusion of technology between the various units within the synthetic textiles sector as well as between this sector and the cotton textiles and ready-made garments sectors. The larger units, which employed qualified and experienced engineers and technologists, are now in a position to undertake major expansion or new mill projects without any foreign expertise. However, they are all dependent upon imported machinery.

Up until 1977, a protected market and repetitive operations enabled the synthetic textile factories to earn high levels of profits. With the liberalization of imports since that time, however, the industry is facing severe competition. Although the larger units, with their trained and experienced technologists, are able to innovate and bring out new products to compete with imports, the smaller units are being driven to the wall.

Methodology and Findings

In these case studies, the entire process of initiation and implementation of each major project in each of the four industries was first disaggregated into the generally recognized stages of feasibility study; engineering; procurement of plant and machinery; construction of buildings and structures; installation, testing, and commissioning of plant and machinery; operation of the enterprise; and subsequent development and expansion. Thereafter, the technology packages involved in each of these stages of initiation and implementation were identified and an attempt was made to determine the processes by which the transfer, absorption, diffusion, and assimilation took place.

Certain common features characterize three of the four industries that have been studied: they began in the 1940s; underwent expansion of capacity by replication at their original locations as well as at locations elsewhere, each expansion program constituting a well-defined major project; were dependent upon a wide range of imported technologies and techniques of pro-

duction with respect to the processes of manufacture, design, fabrication and installation of machinery, and management of production; and the ownership of each industry now rests with a single organization.

The studies focus on the human being as the principal medium for the transfer, absorption, diffusion, and accumulation of knowledge underlying imported technologies and techniques of production. It is the buildup of this human capital within the enterprise that enables the accumulation of technology within that enterprise, which in turn dispenses with or at least minimizes the need for repeated imports of the same technologies. It was found that it is the absorption and subsequent diffusion of these technologies from the individual enterprises, where the transfer first takes place, to other enterprises in related fields in the rest of the economy that enhances the scientific and technological infrastructure of a country. This technological spread and accumulation, in turn, enables the country as a whole to generate its own technologies and techniques of production on a self-sustained basis. The main indicator of the effectiveness of the transfer of technology, therefore, is the buildup of the trained and experienced technological, scientific, and managerial manpower resources of a country, on the one hand, and the entire cluster of manufacturing enterprises, consultancy firms, research and design organizations, and scientific and technical educational and training institutions, on the other.

One of the preconditions for the effective transfer of technology is that, before importing of a package of technologies and techniques of production, it is essential to assemble a group of persons adequate in numbers and with the entire spectrum of skills needed to absorb the knowledge underlying the imported technologies and techniques of production. This becomes possible only if there are within the country universities, technical colleges, and training institutions releasing to the economy a steady stream of engineers, scientists, supervisory and managerial personnel, and skilled workers. In Sri Lanka, it was only toward the latter half of the 1950s that skilled manpower needs for industry were met — and even then, not always fully — from indigenous sources. This was a major handicap faced during the earlier period by all four industries that have been studied. Consequently, they depended upon the services of several expatriate personnel whose experience gained on the job was lost to the country.

Knowledge can be absorbed only in small increments at any stage. If the recipients have some background knowledge — at least at the elementary level — of the technologies involved, absorption becomes easier. This was quite evident from the long time period required to bring the first pulp and paper and cement mills to their rated capacity levels and the shorter time intervals during which the expansion schemes were commissioned and production was again raised to capacity levels.

When there is already technological accumulation within an enterprise, subsequent absorption of related newer technologies becomes easier. This was evident in the case studies.

Absorption is heightened in the "learning-by-doing" process, i.e., by the active involvement of local personnel in all aspects of the work: feasibility studies, engineering, procurement of plant and machinery, installation, and initial operation. Involvement in solving initial setbacks, troubleshooting or problem solving, and research and development activities also heighten the learning and innovation processes.

Better opportunities for absorption of technology and its internalization exist in a large-scale enterprise involved in the entire range of operations from the procurement and processing of raw materials to the manufacture and sale of finished products. In such an enterprise, the knowledge structure is integrated and not piecemeal. Moreover, it is only a large-scale enterprise that can afford to provide adequate technical staff and research facilities for further development of technology.

Continuity of employment, particularly at managerial, technical, and skilled operative levels, strengthens the process of technological accumulation and its internalization within an enterprise and conversely, the external pulls — brain drain and piracy — militate against technological accumulation.

A well-conceived policy of self-reliance at the national level and effective programs at the enterprise level promote the absorption of technology, whereas indiscriminate dependence upon foreign aid and credits tied to technology packages are detrimental to the absorption process.

Assimilation

The existence of an extensive network of scientific and technological education and training facilities within a country is one of the essential prerequisites for the assimilation of imported techniques of production.

A capital goods sector and institutions devoted to the design of plant and machinery and research and development in the field of technology is

another major requirement for an effective process of assimilation.

An overall national policy on technology transfer and an information system relating to the country's technological capability, with special emphasis on its relevance to future industrial policy, should be developed and implemented for maximizing the assimilation process.

The foregoing findings are by no means new discoveries. Their value, however, lies in the fact that for the first time in Sri Lanka the establishment and growth of a few major industries have been sketched in detail, covering a period of about 30 years, and the processes of transfer, absorption, diffusion, and assimilation of technology have been subjected to a critical examination at the micro level. The study illustrates in practical terms, which policymakers at both plant and national levels can readily understand, the factors that facilitate and those that hinder the technology transfer processes. The framework developed in this study could also be refined further and utilized in the future to set standards — in quantitative terms — against which an evaluation of the effectiveness of technology transfer in any new industry or expansion program could be carried out.

Follow-Up Work

In view of the major importance of technology transfer, most countries have developed comprehensive policies on technology transfer and effective organizations for their implementation. Although Sri Lanka does not have an official policy devoted exclusively to technology transfer, the country's industrial and foreign investment policy statements make reference to technology transfer. As a follow-up to this study, it is proposed to trace the relationship between industrial policy and technology transfer.

This would require an analysis of the evolution of industrial policy in Sri Lanka since the 1930s, the development of the scientific and technological infrastructure within the country, and the transfer of technology in selected critical areas. The findings of such a research program would be of value in the formulation of policies for industrial development and technology transfer and for evolving an organization for the collection and dissemination of information on the technological capability of the country.

Comments: Quazi H. Ahmed

The Marga Institute has investigated the absorption and diffusion of imported technology in four industries in Sri Lanka. The industries are: (1) synthetic textiles, (2) paper and pulp, (3) glass, and (4) cement. All of the reports contain good accounts of the historical development of these industries. The reports also contain some information about changes in government policy from time to time and their impact upon the performance of the industries. The researchers have discussed the various issues of absorption and diffusion of technology for all of the industries.

The summary report, which has been prepared for this workshop, does not contain a "summary" of the four studies. It really does not reflect the contents of the reports mentioned above.

In all of the reports, "length of stay of the foreign expert in the mills" has been used as the only indicator of assimilation. In my opinion this is not sufficient and a few more appropriate indicators should be chosen to assess the degree of assimilation more reliably.

In discussing the absorption and diffusion of technology, an attempt has been made to decompose the skills and expertise required for this purpose. Based upon these decomposed factors, the degree of absorption and diffusion that has taken place within the respective industries has been assessed. In my opinion this is an approach that may be followed even though quantitative figures are absent. However, it is felt that there is scope for improving the organization and presentation of the material in this section.

By reading all four reports, one can observe some similarities and differences in the processes of absorption and diffusion. It is felt that it would be very useful if this section could be synthesized into tabular form for close observation and comparative analysis.

It is also observed that there is some scope for further analysis of the data presented in different sections of all of the reports.

With respect to the pulp and paper industry, one can observe that Sri Lanka is still importing the same kinds of investment-related services that it first imported during the early 1950s. It would be beneficial to elaborate on the reasons for such dependence.

Some Issues Pertaining to Technical Change in the Cotton Textile Sector in Sri Lanka

W.D. Lakshman[1]

Technological change, without doubt, is a major factor in the economic development of a country. This has been established in studies about the reasons for growth in advanced countries. This paper constitutes a summary statement of some conclusions from a larger study in which an attempt was made to examine technological change within a selected industry in Sri Lanka. Some of the questions that influenced the direction the study followed are: (1) What are the indicators of technical change pertaining to a given industry? (2) What are the processes through which technical change takes place in an industry? (3) How does such technical change influence growth in the industry concerned and in the economy as a whole?

The study concerned itself with the cotton textile industry in Sri Lanka because of its important position within the country's economy. Moreover, given the relatively long period of time during which the manufacturing of cotton textiles has been practiced in Sri Lanka and the relatively simple nature of textile technology, the cotton textile sector was thought to be a good choice of industry for a case study of technological development.

The cotton industry in Sri Lanka has a number of dimensions. There is the large-scale mill sector as well as the small-scale sector operating handlooms and powerlooms. It is only in weaving that one finds this distinction because spinning and finishing processes are, by and large, found exclusively within the mills sector. Some of the mills are integrated in the sense that they are designed to handle more than one relevant manufacturing process, whereas others are not integrated. The cotton industry, in addition, has a public sector, cooperative sector, and private sector.

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The detailed case study that was carried out excluded the small-scale sector from its scope because of the immense data-gathering problems that were anticipated in a study covering that sector. Again, due to the ease of collecting data, the study concentrates on only five of the public sector mills within the large-scale mill sector. In terms of production, although probably not as much in terms of employment, the mills covered form a large proportion of the country's cotton textile industry. Differences in the patterns of technological change are bound to exist between the mills covered in the study and the rest of the cotton sector in Sri Lanka. Most of the major trends, patterns, and problems pertaining to technological development in the country's cotton sector, however, are expected to be highlighted in a study of public-sector textile mills.

The more detailed study is prefaced by an examination of the country's environment on the grounds that the direction, nature, and extent of technological development within a given industry are influenced by the overall environment. Social conditions in Sri Lanka are a reflection of, as well as a causal factor behind, the low level of industrialization. The nature of capitalism introduced by the plantation investments of the 19th and early 20th centuries was not conducive to promoting an industrial capitalist class. High rates of unemployment and underemployment, resulting from low rates of economic growth, produced a low-wage economy. The working classes lacked industrial skills and discipline. The predominantly rural character of society has been another factor adversely affecting industrialization, but high rates of literacy among the labour force probably provided conditions conducive to easy on-the-job acquisition of industrial skills by the working people.

The overall economic conditions within the country since the 1950s were characterized,

generally, by low rates of growth. In terms of the gross national product (GNP) and employment, the agricultural and service sectors have come to dominate the economic structure. The structure of the foreign trade sector has come to show its inherent weaknesses from the late 1950s in the form of consistent deficits in the balance of payments. Government commercial policy from that time up to 1977 was dictated by these payment difficulties and during this period imports and exchange payments came to be the subject of extensive controls. This "control regime" provided the basis for a process of import-substitution industrialization, with all the problems that attended such industrialization in other underdeveloped countries.

The political system operated through a multiparty setup within which there was a polarization into two main groups. The powers of government changed hands between these two groups on several occasions. Resource allocation mechanisms within the country have come to depend heavily on a political choice mechanism within which the political supporters of governments in power have become powerful agents. The two main political groups have had differences of positions with respect to international power groupings even though both explicitly professed themselves to be nonaligned. In the industry and technology field this has had certain implications, e.g., during the regimes of one of these groups, countries of the socialist block have become important technology suppliers to the country.

One discussion in the main study, of the overall environmental conditions, is followed by an overview of the textile industry in Sri Lanka. Having traced the historical trends up to the late 1950s, a detailed examination of government policy and the development of the domestic textile industry since that time has been attempted. Growth of domestic production and some of the attendant problems have also been discussed. The composition and relative size of the industry and the institutional structure that had a bearing on the industry have been examined as well.

Market conditions, both product and input markets, determine the nature of technological developments within any industrial field. Product market size has been roughly ascertained in the study to show that up to 1959, availability of textiles was adequate to meet market requirements but not generally so after that date. The product market was sufficiently large to sustain a growing textile industry in the country, particularly in the cotton field. The potential market that existed even prior to 1959, however, became an effective market only after protective measures taken since that time. The product market conditions dictated the following technological needs: (1) import controls on cotton textiles and their essential nature in consumption patterns made adoption of technologies necessary that could ensure quick expansion of domestic production and (2) the quality composition of the market made the handloom sector a poor source to meet market demand.

Thus, from the point of view of product market characteristics, acquisition of mill technology into the cotton sector was needed. Given the country's factor endowments, handloom technology was, perhaps, more appropriate. The compromise policymakers seem to have sought here is indicated by their consistent attempts to simultaneously promote the mill sector as well as the handloom sector of the cotton industry within Sri Lanka.

Although domestic production of cotton textiles grew in response to product market needs, the industry remained heavily dependent upon imports to obtain its needed inputs. This was particularly evident in the case of raw cotton. Domestic supply of raw cotton remains, even today, a very low proportion of what domestic industry can use, in spite of relatively rapid expansion of raw cotton production during the recent past — a rapid expansion because of the very low base from which local production started. Policy in manufacturing and agriculture in this respect was uncoordinated. One is tempted to question the adequacy and advisability of the strategy of depending upon small farmers to promote cotton cultivation.

Labour market conditions affecting the growth of the cotton industry have also been reviewed. The annual output from the educational system and the drain of skilled personnel from the country have been considered in relation to the needs of the industry for technically competent personnel.

Scarcity of foreign exchange and capital has been a serious constraint on the growth of the domestic textile industry. Often, technological choices were dictated by such extraneous factors as the availability of foreign resources rather than by valid economic considerations. This is clearly shown in the choice and transfer of technology into the public sector of the cotton industry. Of the five public sector mills studied, four are equipped with technology obtained from two socialist countries — the German Democratic Republic (East Germany) and the People's Republic of China. The choice of machinery,

equipment, and know-how from these sources was hardly the result of a free choice. The government, wanting to expand textile manufacturing capacity, was not in a position to shop around for the needed machinery and equipment due to a lack of the necessary exchange resources. When project aid was made available by these two countries, the mills provided under this aid were accepted with no inquiry into the appropriateness and efficiency of the machinery and equipment involved.

The technological capability of the domestic cotton textile industry depends upon the degree of its absorption and diffusion, which, in turn, are influenced by overall environmental conditions, market conditions, and the nature of technology transfer. An attempt has been made to measure the degree of absorption of imported technology on the basis of existing levels of knowledge, experience, and confidence of top technical staff of five public sector mills under the National Textile Corporation (NTC). On the basis of a point scale, with a possible maximum of 100, the degree of overall absorption of technology has been measured at 34%, a rather low level given the length of time the country has been manufacturing cotton textiles. A lot of valuable information is, of course, hidden behind this overall figure. People seem to be more capable in process technology than in engineering technology and related research and development work. They seem to be more capable in weaving and spinning techniques than in finishing. The degree of absorption of technology is also seen to be varying in the different subareas under spinning, weaving, and processing.

The measure of technology diffusion used is the proportion of the market requirements of the cotton textile industry actually satisfied by the products of the mill sector. Although the machinery and equipment used in these mills are far from being uniform, the mill sector and decentralized powerloom sector are taken here as representing one particular type of technology distinct from the handloom technology adopted in the rest of the cotton sector. It is, of course, only weaving which is taken into account in this measure of diffusion. Starting with a very low degree, diffusion of imported textile technology spread to reach an average of 36% between 1973 and 1976. It was found that protective measures were also important in promoting diffusion of imported textile technologies.

The degree of assimilation of imported textile technology into the local environment, defined as the degree of self-sufficiency of the country in the input requirements of the local textile industry, has been poor. Spare parts, accessories, and chemicals required by the industry, estimated at approximately Rs105 million (U.S.$5.85 million) per annum, are mostly imported. Dependence of the industry upon imports for its raw cotton requirements has already been noted. In the past, expatriates have worked within the domestic industry, but today, except for those working on the installation of the finishing sector of one of the mills studied, no foreign personnel are employed. (This is prior to the handing over of the management of NTC mills to foreign firms.) All managerial and other posts are staffed by nationals. In the case of technological imports, the average degree of assimilation achieved between 1973 and 1977 was 49%. A closer examination of the gross incomes generated and the foreign exchange utilization by the NTC between 1973 and 1977 indicates that for every Rs100 (U.S.$5.57) of value-added, foreign exchange equivalent to approximately Rs133 (U.S.$7.41) was utilized.

In spite of the deficit supply position in the market (1967-1976), the mill sector never reached even 50% of its total rated capacity. Although foreign exchange shortage was partially responsible for this, the main cause seems to have been the high incidence of machine downtime. This resulted, among other things, from the low level of absorption of adopted technology. The low level of capability in engineering technology resulted in inadequate plant maintenance, frequent machine breakdowns, and the consequent low level of plant capacity utilization. In the case of the NTC, therefore, the actual value-added was as low as 37% (on average during 1970-1977) of its potential.

If the benefits of adopting imported technology for economic development are to be optimized, adequate policy changes and incentive measures are required to: (1) ensure the development of a sound technological engineering base, (2) promote exportation of the finished product, (3) encourage local manufacturing of intermediate inputs, and (4) ensure optimum utilization of the productive resources.

Using the terminology adopted in the study, this requires the promotion of the degree of absorption, diffusion, and assimilation of imported technology. Problems faced by the domestic textile industry after import liberalization in 1977 indicate that the domestic industry has still not reached a stage at which it is able to compete with imported products within a system of free trade. Some protection is still required but

the system of protection provided has to be well planned to promote growth of efficiency. One of the main factors contributing to poor competitiveness of local textile product is their relatively poor quality. This probably requires modernization of existing production facilities. During a transitional period of protection, the existing industry has to be encouraged to provide its own resources, i.e., capital and foreign exchange, to undertake plant modernization, particularly in the case of public sector firms.

The industry seems to have capable and knowledgeable technical people but the autonomy of decision-making given to them, in the public sector of the industry, is minimal, not only in the choice of technology but also in the day-to-day management of the mills under their authority. In order to give them greater responsibility there has to be a change in the attitudes of those in power. Introduction of incentive schemes to promote innovative decision-making is also required.

Manufacturing activity in any particular area has its linkages with productive activity in other areas. Promotion of these linkages, particularly the backward linkages, is necessary to optimize the benefits of expanding any industry. Close coordination of related activities is, therefore, necessary. This often requires, as shown in the present study, institutional reforms. In Sri Lanka, there is a Textile Industries Ministry, but cotton growing continues to be under the authority of the Ministry of Agricultural Development. Necessary institutional linkages between these two ministries and other relevant bodies are indispensable if industry linkages are to be made use of for more rapid and sustained industrialization.

Comments: Luke Kho

This paper has a very informative section on the development of the textile industry in Sri Lanka from the historical perspective, particularly due to its suggestion that its evolution is a result of the interaction of productive forces from various power groups: namely, colonial, British capitalist, "comprodore bourgeoisie," etc.

The paper also focuses on the growing literacy of and shrinking employment opportunities for its vast labour force as a consequence of the country's "failure to develop an industrial technology infrastructure."

The definitions of ADIT require more specification and the subsequent quantification requires greater methodological linkages and logical basis.

Absorption, Assimilation, and Diffusion of Imported Technology in Pakistan: A Case Study of the Textile and Pharmaceutical Industries

Firasat Ali[1] and Jamal Ahad Khan[2]

The purpose of this study is to describe, analyze, and evaluate technology transfer and its absorption and diffusion within the textile and pharmaceutical industries of Pakistan. The study focuses on the mode, means, and cost of technology transfer in an attempt to answer the question of why, what, and how technology is transferred. The mode and means have been evaluated in the light of government policies, characteristics of supplier and recipient, contractual framework under which the transfer is effected, structure of participation, and negotiation processes. The analysis of cost was carried out to ascertain its importance on balance of payments, the situation of the country, and its influence on macrolevel indicators such as employment and income.

Problem Areas in Technology Transfer

The problems associated with the process of technology transfer in Pakistan include:

(1) Inability of the government to procure technologies that are best suited to the needs of the country due to: the government's dependence upon the technology supplier for information and advice related to the technology being imported, subsidiaries of multinational firms procuring most of the production techniques from their parent firms without involving government in the selection, dominance of foreign investors in cases where technology is imported through joint ventures involving both local and foreign capital, foreign technical assistance from international organizations frequently being oriented toward nonpriority fields, and tied loans offered by developed countries limiting the role of government in the selection of technology.

(2) Lack of technical capacity in various sectors of the economy causes difficulty in defining the problem that requires the import of technology. A further lack of information about the type of technology required to solve the problem and its source leads to the procurement of inadequate and expensive technologies, which hinders the incorporation of the technology into the productive process and makes absorption difficult.

(3) Technologies imported are inadequate to meet national development needs, e.g., labour-intensive technologies should be imported in order to make use of Pakistan's surplus of labour.

(4) Lack of capabilities for searching for appropriate technologies and for the evaluation and absorption of imported technology in the private sector due to the limited capacity of public institutions to advise the private sector and because technical and research and development institutions have not been approached to deal with this problem.

(5) Costly and ineffective technology transfer due to conditions imposed by the supplier as part of the technology procurement deal.

(6) The role of subcontracting as a means of technology transfer has not yet been realized.

(7) Lack of coordination among various government agencies and overlapping in their functions. Because various agencies are involved at different levels in the import of technology, the selection of appropriate technology is difficult. In addition, there is a lack of communication between policy-executing agencies and technical and research and development organizations and the government, which results in the government

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being uninformed about the technological competence of these organizations. Similar communication problems exist within the private sector.

Policy Measures Aimed at Improving Technology Transfer

Several policy measures aimed at resolving Pakistan's problems related to the import of appropriate technologies and their rapid absorption and diffusion have been established. To formulate and implement these policies, a national system for technology development has been proposed. The National Commission for Technology Development would be the highest national body within this system and would be responsible for formulating the goals and objectives for the technological development of the country. To assist the National Commission for Technology Development in implementing its policies, a Technology Development Board is proposed. This board would function through two separate units: Indigenous Technology Development Cell and Imported Technology Cell. The Indigenous Technology Development Cell will promote indigenous technologies to assist entrepreneurs in their technology development efforts and provide assistance to units engaged in capital goods manufacturing. As well, it will develop data on indigenous technologies and the absorption and diffusion of imported technology and act as a liaison between innovators and research institutes and financial institutions. The Imported Technology Cell will deal with the import of technology into the country through receiving applications for the import of technology and giving sanctions. It will also act as a coordinating agency between the entrepreneurs and financial institutions. To provide logistical support for the entire system, an institutional framework will be used. In this regard, the establishment of a data bank; research development corporation; forum for capital goods manufacturers; and an agency to evaluate, monitor, and follow-up technology development will be set up. Additional institutions will be created as required.

In addition to the national system for technology development, an Information Development Centre is proposed. This centre will act as a repository for all available technological information that meets the needs of agricultural, industrial, research and developmental, and governmental bodies. The information system will play a vital role in developing science and technology policy that will, in turn, determine priority areas for data information collection and dissemination. In this way, the information centre will act as a coordinating body between the various agencies involved in the development of technology in Pakistan.

The actual formulation of federal policies incentives for technology development, utilization, and diffusion will be made at the Cabinet level, based on information supplied by the Ministries of Science and Technology, Agriculture, Industry, Education, Commerce, and Finance.

Some broad policy measures will also have to be established to meet the demands for technology transfer. For example, appropriate training and education is important if a country is to develop and become self-reliant; the needs of the masses must be met by selecting technologies and implementing projects in areas that suit balanced development; a relationship between supplying countries and recipient countries must be developed to facilitate technology transfer; a science and technology plan must be developed to deal with technological manpower, service technology infrastructure, industrial technology, and public understanding of the issues involved; all technologies should be appropriate to the social and economic environment prevailing locally; efforts must be made to increase the number of training facilities available if technological manpower requirements are to be met; industry and government must provide opportunities within their systems for employees to develop administrative and managerial skills; and research and development should be promoted.

Problems Facing the Textile Industry

Pakistan's textile industry is confronted with several problems requiring resolution:

(1) There are many instances of articles being placed on the free list for import despite the fact that sufficient production facilities exist locally for the same goods.

(2) Virtually all textile mills complain of market constraints in the utilization of technology due to competition from foreign cloth, which finds its way illegally onto the domestic market.

(3) Many fiscal anomalies exist, with the result that raw material is heavily taxed, whereas subassemblies and finished goods are allowed to be imported with relatively low import duty.

(4) There are cases where the import duty rate has been increasing simultaneously with the cost

of raw materials abroad. The consequent increase in the cost of production has seriously affected the profitability of manufacturing concerns.

(5) Inaccurate interpretation of the nomenclature has often lead to tax evasion and malpractice.

(6) The price of cotton is based on ad hoc decisions. Frequently, cotton is not available at the price and illegal dealings occur at higher prices without intervention by government bodies. The sudden decrease in the price of cotton, when the present regime came into power, caused significant losses to many textile mills that had stocked large quantities.

(7) The procedure for rebate of customs duty on raw materials and subassemblies, used in the manufacture of local machines, is cumbersome. Machinery manufacturers generally cannot afford to keep large stocks of raw materials and parts. They purchase a small stock from the local market when required. Suppliers of the raw materials and parts do not provide sufficient information to satisfy customs rebate procedures. In addition, the rebate is allowed only after the imported raw material part has been utilized in the manufacture of a new machine. Because of this, the amount of money that is legally refundable is blocked for a considerable length of time.

(8) Several textile mills complain of a heavy incidence of tax and the procedure of double taxation.

(9) Water and Power Development Authority (WAPDA) tariff rates, compared with 1976, show an average increase of 38% for different loads and a 76% increase per unit. Karachi Electric Supply Corporation tariff rates show an increase of 25% in billing and 170% for additional energy charges per unit. The consequent increase in the cost of production for the ailing textile industry must be considered before such increases are made. Perhaps, special rates should apply to the textile sector until it recovers.

(10) Some textile mills are facing a power shortage. Perhaps, such mills should be allowed to import electric generators without payment of any duty.

(11) Interest liabilities of several mills have reached prohibitive levels. Serious consideration must be given to waive these charges or reschedule payments at reduced rates.

(12) The 10% surcharge in tax liability has further increased the cost of production. The prices of spare parts, accessories, industrial raw materials, dyes and chemicals, etc. have increased accordingly. The abolition of this surcharge must be considered.

(13) Balancing, modernization, and replacement (BMR) is a continuous process. The limiting of the time period for concessions in BMR is not appropriate for the textile industry.

(14) Despite the fact that machinery for BMR is imported under a valid import licence, which takes about 6 months to obtain, industrial units are required to obtain an Exemption Certificate from the Textile Commissioner, Karachi. It should be noted that the exemption is not necessary because the list of machinery not entitled to exemptions is clearly defined. This formality requires an additional 4–5 months. The inconvenience, time lost, and need for frequent travel to Karachi is a disincentive for BMR, as well as a waste of resources.

(15) A further requirement of BMR is that the existing old equipment be scrapped. Measures should be employed to overcome wastefulness of resources in this manner.

(16) The licence fee of 1% for an import licence, up to a maximum of Rs0.1 million (U.S.$10 000), was levied prior to devaluation by 131%. The same rate continues today.

(17) Textile mills complain that insurance claims are not paid on the basis of goods insured but on the cost and freight value, and settlement of claims takes a long time.

(18) There are complaints regarding damage, theft, and pilferage of imported goods during loading, unloading, and storage in warehouses, for which nobody bears the responsibility.

(19) To promote export in a buyers market (textiles), the government should consider subsidizing export.

(20) Because locally produced gums are substandard and not available in sufficient quantities, they must be imported, for which there is a prevailing import duty of 120%, plus an additional 10% sales tax. Moreover, the Customs Department views "thickeners" as banned items. Because local gums are not stable under acidic and alkaline conditions, which are the important media for transferring the dye stuffs into the fabrics, the government must consider the import of glue at a reasonable cost to the mills. This is imperative because printing charges have decreased from Rs5 to Rs2.50 (U.S.$0.50 to U.S.$0.25) per metre.

(21) Local capital goods and spare parts manufacturers are not producing bolting cloth and rotary screens for making printing designs because the import duty is 85%, plus 10% sales tax.

(22) Lacquers and emulsions are important for screen making. Local industry does not manufacture fancy chemicals, yet the lacquers and emulsions used for textiles are banned.

Pakistan's Experience with Imported Technology

Pakistan did not inherit any significant industrial base at the time of independence, which made the import of technology necessary. The technology import influx did not decrease with the passage of time, however, because the proper environment was not created for effective absorption, assimilation, and diffusion of imported technology in the various sectors of the economy. The major sufferers in this respect are local machine manufacturers who, in spite of having a good technological capability level, cannot play their part in making Pakistan self-sufficient in some of its technology requirements.

A policy of continued dependence upon imported technology directly affects the growth of the local capital goods manufacturing sector, which has happened in the case of Pakistan. With the changing situation around the world, no developing country can rely indefinitely upon imported technology as a means for development. It has become essential for a developing country such as Pakistan to create an environment conducive to duplicating imported technology. A stage may come later when the duplicated imported technology can be improved further, as in the case of Japan. The most essential requirement to achieve this objective, however, is the creation of an appropriate base. This can be only achieved through close cooperation between government, policymaking, financial, and research and development agencies. Contradictory policies that affect the growth of the local capital goods sector will have to be abandoned and new blood will have to be infused into this sector by providing the proper incentives.

The importance of building up indigenous technological capabilities expeditiously was generally lost sight of under the pressures resulting from food shortages, rapidly growing population, and other sociopolitical problems, and above all, the absence of the trained manpower required for the planning, evaluation, selection, and adaptation of technology transfer. No institution existed to plan the transfer of technology according to needs, evaluate various alternatives available for the import of technology, select the proper type of technology, negotiate the most favourable terms, or develop the capability to assimilate the technology.

The adverse effects of the absence of a proper institutional mechanism and a well-coordinated policy for acquisition of technology are reflected by the present state of Pakistan's spendings in the form of royalties, technical fees for consultancy, trademarks, and licences. During the 5 years between 1965 and 1970, Pakistan spent an average of $102 million annually on patents, know-how, trademarks, and management and technical services. According to careful estimates, the annual average for the last 8 years has risen to about $175 million. The component of expenditure is one of the highest amongst the countries of the region. This clearly indicates that the country will continue to depend heavily upon foreign sources of technology and pay exorbitant prices for such transfers unless serious efforts are made to enhance the national science and technological capability and support national research and development institutions that are presently working at subcritical levels without sufficient financial and manpower resources.

In 1978, the cost of imported technology was estimated to be approximately Rs177 million (U.S.$17.7 million). The breakdown of technology costs is given in Table 1.

Technology has been transferred in Pakistan mainly through licencing or joint ventures. The licencing agreements are normally process- or product-oriented and involve high payments for the licence. Royalties and the costs of licencing agreements have been as high as 3%, followed by a royalty of an equivalent percentage on the price of goods produced.

Most licencing agreements with Pakistani firms relate to patents and trademarks. A sample study revealed that about 37.5% of the licences are for the use of trademarks. Licences for the use of patents and patent technology are obtained by about 42.8% of the technology importing companies.

Licencing has remained almost entirely limited to a small number of individual enterprises, which has prevented further dissemination of general technological development throughout the country. The distribution of licence agreements has also been unbalanced and emphasis has remained on consumer goods, with very little attention being paid to intermediate and capital goods. Frequently, the licensees of patents trademarks

Table 1. Technology costs (thousand rupees).[a]

Technology	1964 1965	1965 1966	1966 1967	1967 1968	1968 1969
Capital equipment	50.3	22.0	45.2	51.0	74.9
Royalties and trademarks	7.4	9.0	16.3	10.5	7.4
Technical fees	64.6	32.7	33.3	36.2	4.4

[a]Re 1 = U.S.$0.1.

are also obliged to seek additional technical information in addition to further payment.

A recent study of technology transfer contracts has shown that they contain various types of restrictions on exports, the purchase of spare parts and intermediate products, and the pattern of production, as well as financial restrictions that affect the validity of patents, etc. The results of a study of 54 contracts are summarized in Table 2.

Regarding technology transfer through joint ventures, the technology transferring agencies often succeed in syphoning as much revenue as possible through expatriates, service charges, and other costs. The situation warrants revision of the international patent system, on the one hand, to make it more realistic and take into account the problems faced in developing countries such as Pakistan, and, on the other, to enable the governments of such countries to take measures such as creation of technology evaluation institutions, which would assist the local entrepreneurs in making the proper choice of technologies and negotiating more reasonable terms in licencing agreements. In such efforts, assistance from United Nations agencies may prove to be of great value for making available the necessary information/data from different countries.

Table 2. Evaluation of restrictions in transfer of technology contracts.

Type of restriction	Percentage of contracts with restrictions
Territorial restriction	
Requires prior approval of licensor	31.4
Export only to certain countries	12.9
Restrictions on source of:	
Raw materials	27.7
Spare parts	16.6
Intermediate products and capital goods	25.9
Competing technologies	14.8
Restrictions on pattern of:	
Production	18.5
Sales and distribution	14.8
Financial restrictions	
Long term of enforcement	38.8
Discriminatory royalty	25.9
Limitations affecting the technology	
Absence of provisions regarding training	22.2
Grant-back provision	42.5
Other restrictions	
Not to contest validity of patents	24.0
Foreign law governing agreement	23.3
Foreign jurisdiction in settlement of disputes	33.3

Efforts at the international level, in this regard, should ensure:

(1) International technology transfers promote national and collective self-reliance of the developing countries in scientific and technological fields.

(2) International scientific and technological cooperation and optimum use of world resources for the equitable benefits of all member states.

(3) Nondiscrimination in conditions for the supply of technologies on fair and equitable terms to developing countries; including nuclear technology for peaceful purposes.

Elements of Transfer in Various Industries

In developing countries, labour-intensive processes are desirable. The introduction of new processes, however, is difficult. Therefore, an underdeveloped country such as Pakistan cannot afford to adopt new processes unless the prospects of success are high. The manufacturing processes in Pakistan, transferred from developed countries, fall into two categories: new processes and modified processes.

New processes are processes that have not previously been available within the country but their success has been proven in similar economic and industrial climates. For example, machine tools manufacturing in Pakistan has started very recently. Therefore, all processes brought into this sector are new. The percentage of technology imported with new processes in engineering, chemical, and electrical industries, on the other hand, is 25, 26, and 41% respectively.

The primary reason for not importing up-to-date technologies is the lack of experience of local industrialists concerning the worth and value of the technology. Another reason is the lack of interest of government agencies and institutions because they are more concerned about the financial soundness of both the supplier and recipient enterprises. The government makes little effort to study the nature of imported technology and its chances of diffusion within the country. Similarly, no investigations are made to determine the prior status of the technology and its degree of assimilation within the country. As such, the rate of duplication of technologies is high compared with the rate of diffusion of imported technologies, which is low.

Table 3. Channels for technical and managerial know-how (%).

Channel	Engineering	Machine tools	Chemicals and fertilizers	Electrical	Pharmaceuticals
Assembly techniques	96.0	100.0	82.5	91.0	71.5
Documentary information	100.0	100.0	100.0	100.0	71.5
Preinvestment studies	12.5	66.0	13.7	22.7	14.3
Project reports	25.0	66.0	23.5	36.4	35.6
Plant design fabrication	100.0	100.0	100.0	100.0	100.0
Erection and installation of plant	83.3	100.0	100.0	100.0	100.0
Plant management	12.5	33.0	21.5	26.7	35.7
Organization of research and development	8.5	100.0	19.6	31.8	71.5
Training of local personnel	66.7	66.0	68.8	65.0	

According to a survey, the percentage of process modification in various sectors is: engineering industries, 12.5%; machine tool industries, 33.0%; chemicals and fertilizers, 11.7%; electrical industries, 27.3%; pharmaceuticals, 14.3%. The modifications have been made either due to the danger of obsolescence or due to market limitations.

In chemical industries, modifications and improvements are generally made in view of special environments regarding local inputs. In the pharmaceutical industry, the major portion of modifications is made in accordance with improvements introduced by the parent company in production processes.

Technical and managerial know-how is one of the major elements in the process of technology transfer. For Pakistan, it constitutes an important channel through which technology has been transferred on an enterprise-to-enterprise basis as depicted in Table 3. Technical know-how has also has been imported in the field of planning and supervision. The greatest amount of technology transfer, however, has been facilitated through the sale of equipment in the various sectors of industry in Pakistan.

Absorption and Diffusion of Imported Technology in the Textile Industry

Plant layout and design have always been undertaken by Pakistani-trained engineers. Expatriates generally supervise the erection and installation of machinery, however, despite the fact that this skill has been thoroughly absorbed and diffused within Pakistan. This is generally done to avail the guarantee clause of foreign machinery manufacturers.

Research and development are the two factors lacking within the textile industry. Government policies have not favoured such undertakings. Almost nothing has been imported through this means.

Technical, financial, and personnel management are poor compared with European mills. However, nothing worthwhile has been imported directly. Virtually nothing has been imported in marketing and textile mill owners are generally shy of consulting expertise (which is present in Pakistan) to assist them with their management and marketing problems.

Product design generally consists of copying imported products with very little local input. Practically no technology has been imported directly by textile mills for designing products, and because it is not a significant feature of the industry, the existing units are quite self-reliant.

Preventive maintenance is carried out by most mills. Due to the age of the machinery and a lack of details, however, the product is generally not up to the standards of European mills. However, because they do not avail themselves of foreign expertise in this matter and are able to schedule and manage preventive maintenance on their own, the knowledge and techniques can be considered to have been absorbed by the industry. Several mills have been able to innovate on imported machinery with good results. Diffusion of this know-how, however, has been negligible.

Conventional inventory control is still employed. There has been no direct import or absorption of this know-how.

All relevant quality control methods are known to textile workers. However, they are partially deficient in the calibration of quality control equipment. They have no knowledge of the maintenance of quality control equipment.

Absorption and Diffusion of Imported Technology in the Pharmaceutical Industry

Pakistan is self-sufficient in technical personnel requirements. Pakistani nationals have acquired considerable expertise from expatriates, with the result that they can be compared with any other professional around the world. Furthermore, there are many Pakistanis with foreign post-graduate qualifications and experience in different aspects of the pharmaceutical industry.

Subsidiaries of foreign firms and the larger local firms established themselves with imported machinery and equipment. Those in the early 1950s even imported minor equipment such as buckets, which were readily available in Pakistan. In the late 1960s and later there has been a general shift toward locally manufactured machinery because of several factors, the foremost being that local machinery is 40% cheaper than imported machinery and is just as efficient. Sophisticated machinery, which cannot be manufactured locally, is still imported. Small local firms depend entirely upon local machinery manufacturers. This shows the extent of assimilation that has occurred in the past two decades.

There is considerable know-how present locally in terms of designing plant layout, etc. Despite this fact, foreign subsidiaries supervise design through their expatriate staff. Local firms rely completely upon indigenous skill and know-how.

Pharmaceutical firms of Pakistan are able to modify and adapt drugs to suit local requirements if the need arises. This has been done in several cases; however, they do not possess the funds, facilities, or know-how for research and development regarding new drugs. The Pakistan Council of Scientific and Industrial Research has been able to prepare certain basic drugs independently. Local firms, which do not have a licence to manufacture foreign patented drugs, utilize pharmacopoeias and conduct sufficient research and development so that they are able to manufacture them on an industrial scale.

There is considerable import, absorption, and diffusion of technology through literature and foreign magazines concerned with pharmacy and medicine.

All the subsidiaries of foreign firms had expatriates as their top management during the initial years of development. They were later replaced by local personnel. Because most local managers claim that during the latter period the company functioned better, it is safe to assume that the imported know-how was completely absorbed and innovated to suit local requirements.

Many local firms copied the management structure of foreign subsidiaries. There was, therefore, considerable diffusion of technology in this respect. Similar comments can be made for marketing know-how and techniques.

Larger firms were well aware of the concept of preventive maintenance and utilized it with the help of Pakistani staff. Much of this knowledge has come through maintenance journals, expatriate staff, etc. It is fully absorbed by the local people. For financial reasons, however, very small local firms do not utilize preventive maintenance.

Quality control is effectively carried out by Pakistani staff; some of them highly trained. The equipment used by some of the leading firms is modern. All the techniques have been absorbed but they still rely upon the agents of the manufacturers of the quality control equipment to maintain it. These agents are Pakistanis who have been trained in the field by expatriates.

Inventory control is being practiced by foreign subsidiaries along the lines set by expatriates who have since left. This shows that they have fully absorbed the imported know-how. Some of this know-how has diffused to local firms through the transfer of personnel.

Comments: Woo Hee Park

These comments refer to both Pakistan's comprehensive report and the summary report prepared for the workshop, the latter having been edited substantially for inclusion in these proceedings.

The report has four main components: (1) scope and methodology; (2) policy guidelines, together with a macroreview of industrial development; (3) a macroreview of transfer issues; and (4) a set of case studies on textiles and pharmaceuticals.

The case studies are the major contribution of this report, in which the topic of absorption and diffusion of imported technology is touched upon. Parts III-5, IV-4, IV-6, profiles of the surveyed units in parts III and IV, and Table 7.10 (technological capability levels of the firms) are very interesting.

There are, however, problems with the report in its present form. In brief these are:

(1) Substantial general editing is required. The policy guidelines and macroreview of transfer issues portions are fuzzy and parts seem to be irrelevant to the topic. The technology-oriented component of the introductory macro-review seems to be weak, not well organized, not well presented, and with a "drift" of argument that seems to lie somewhere between "not very convincing" and "dubious." There are a number of detailed problems with the data presentation and analysis.

(2) Policy suggestions do not pull together very well the main threads of the empirical case studies. Also, little evidence is provided to support the generalizations or assertions in policy implications.

(3) More important are serious problems with the scope and methodology section, which does not relate to the empirical studies of the textile and pharmaceutical sectors. Definitional clarification is essential in this study, where much variation and confusion in usage seem to prevail.

(4) The main problem relates to the absorption or assimilation concept — a process of learning to relate to bodies of knowledge and a state, e.g., the level of local execution of tasks varies. Inherent in the definition of absorption as a process of learning is the need to distinguish between the process and various performance indicators from which one can infer something about the rate and qualitative nature of the process. A relationship between absorption learning, on the one hand, and performance, on the other, should be clarified.

(5) A slightly less serious problem relates to the diffusion concept. What is shown in the text is a pattern of local supply of parts, etc. What is not shown is the role which diffusion of technological knowledge plays within that process. What technological knowledge is diffused from the initial importing enterprise to other suppliers? To what extent did they already have the technical know-how necessary to supply the parts and equipment?

(6) The evidence presented does not seem to support the question of whether absorption and diffusion are, in fact, fast or slow. Furthermore, there is no indication of against what yardstick absorption and diffusion are so firmly and repeatedly judged to be slow or fast.

(7) No distinction is made between operating performance and design capacity. Also, it is not clear whether the cost reduction results only from the physical input/output charges, i.e., cost savings at constant input prices or whether they include an element of price charge as well.

(8) No measurement has been made at all of the ADIT problem.

In summary, more emphasis should be directed toward the absorption and diffusion of imported technology, which is a neglected area and one of considerable academic interest as well as one of widespread practical, policy-oriented relevance for industrialization and development of self-reliance within developing countries.

Technological Change, Transfer, and Diffusion in the Textile Industry in India

Amitav Rath[1]

The textile industry within India is very large and well established, with a long history. Because of its size and history almost all branches of the industry have a domestic base. Cotton is the major raw material required by the Indian textile industry, with most of the cotton consumed being grown within India. India has the largest acreage allocated to cotton of all countries and is fourth in cotton production. Prior to the establishment of an organized textile industry in the middle of the last century, a large portion of the country's cotton was exported. Among the natural fibres, wool and silk are of some importance but will not be discussed here.

Man-made fibres used in the Indian textile industry include rayon, polyester, acetate, and nylon. Small quantities of acrylic and other fibres are imported. Domestic production of acrylic fibre, however, is expected to commence soon. The availability of different raw materials for the textile industry in India is indicated in Table 1 for a few selected years.

Spinning of yarn is carried out both in the modern mill sector and as a household activity using simple hand-operated spinning wheels. Even though spinning of yarn by hand is encouraged by the government, it has not been economically viable. Over the last 20–30 years, handspun yarn has accounted for less than 0.1% of the total yarn produced; the balance being produced in the mill sector.

The mill sector can be divided into two groups: spinning mills, i.e., mills that do not weave any cloth or carry out any processing of cloth and sell all yarn in the market, and composite mills, which have looms and some processing facilities, with the degree of processing varying from mill to mill. Composite mills spin the yarn, weave the cloth, and may also dye, bleach, and print the fabric produced. These mills may sell a part of the yarn and unprocessed cloth in the market, and sometimes process cloth for other manufacturers. The composition and growth of spinning and weaving mills are indicated in Table 2.

The weaving of cloth is carried out in three ways: some of the yarn is woven in the mill sector

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Table 1. Raw materials used by the textile industry in India.

Year	Cotton production (× 10^6 kg)[a]	Cotton imports (× 10^6 kg)	Viscose		Nylon		Polyester	
			Production	Imports	Production	Imports	Production	Imports
1951–52	557		2.5					
1954–55	753		15.5					
1959–60	655	202	41.0					
1964–65	1019	109	72.3		1.5		1.4	
1969–70	946	121	99.2		9.8		5.8	
1974–75	1216	31	99.8	0.1	13.4	1.5	16.8	1.2
1977–78	1207	93	134.1	15.0	18.0	0.5	32.0	2.5

[a] Government estimate of cotton production: includes loose cotton, approximately 50–60 million kilograms; exports and nonmill consumption, approximately 60–70 million kilograms.

Source: Indian Cotton Mills Federation. Annual survey statistics of the textile industry, 1950–1978.

Table 2. Growth and composition of spinning and composite mills.

Year	Spinning mills	Spindles installed (× 10^6)	Composite mills	Spindles installed (× 10^6)	Looms installed (× 10^3)
1948	88	1.6	268	8.5	192
1950	94	1.9	268	8.7	191
1955	116	1.8	292	10.2	203
1960	186	2.9	293	10.7	200
1965	253	3.9	290	11.5	206
1970	366	5.5	290	12.2	208
1975	403	6.5	288	12.3	207
1978	357	7.8	291	12.4	207

Source: Textile Commissioner, Indian Textiles Bulletin, Various editions, 1962–1979.

and some is woven by the decentralized sector, with part of the production in the decentralized sector being on power-operated looms of a design similar to those used in mills, and the remainder is woven on handlooms.

Statistics on the production of cloth by mills are prepared from detailed monthly statements that mills are required by law to submit to the Textile Commissioner's office. The data furnished by the mills include details on the types and levels of activity of machinery, consumption of cotton, production of yarn, consumption of yarn, and production of cloth.

Statistics on cloth woven in the decentralized sector, on the other hand, are less accurate. They are determined by substracting the yarn consumed by the mills to produce cloth from the total production of yarn, the difference providing an estimate of the yarn consumed in the decentralized sector. The estimate of cloth produced in the decentralized sector is then arrived at by multiplying the weight of yarn by an estimated conversion rate of 9 m of cloth production per kilogram of yarn consumed. Table 3 provides some details of spun yarn production in India.

Table 3 indicates that whereas in 1970, 100% viscose rayon yarn was the only type of man-made fibre yarn of any importance and accounted for 6% of production, by 1978, significant growth had taken place in the use of viscose, polyester, and blends. Based on the production of yarn given in Table 3, the consumption by the mills and decentralized sectors is indicated in Table 4. The estimated production cloth is indicated in Table 5.

Table 3. Spun yarn production (× 10^6 kg).

	1970	1975	1978
100% cotton yarn	965	989	912
100% viscose *	62	53	86
100% synthetic (mainly polyester)	2	2	6
Polyester cotton blend	8	11	15
Polyester viscose	3	7	24
Cotton viscose	6	19	164

NOTE: * This does not include filament yarn.

The textile industry is subject to a large degree of government control. The major objectives for which policies are designed include: (1) protecting employment and income in cotton farming; (2) achieving an adequate supply of cotton for domestic consumption and exporting; (3) improving the yield and quality of local cotton; (4) stabilizing cotton prices and supplies; (5) providing increased employment in spinning and weaving; (6) providing a stable price for cloth and ensuring the production of cheaper varieties for consumption by poorer people; (7) improving international competitiveness and earning higher amounts of foreign exchange; (8) increasing government revenue through production levies on cloth production; (9) increasing domestic machinery manufacturing capability; (10) increasing export earnings and reducing imports of machinery and spare parts; and (11) preventing monopolies within the man-made fibre industry. It is clear that although each objective is desirable

Table 4. Yarn consumption within the mills and decentralized sectors (× 10^6 kg).

	1975		1978	
	Mills	Decentralized weavers	Mills	Decentralized weavers
100% cotton yarn	513	438	432	449
100% man-made fibre yarn		51	5	99
Blended yarn	23	17	104	96

Table 5. Cloth production (× 10^6 m).

Year	Mill sector		Decentralized sector
	Cotton cloth	Blended cloth	Handloom and powerloom cloth, cotton and blends
1950	3351		911
1955	4658		1620
1960	4616		2013
1965	4587		3056
1970	4157	109	3692
1975	4032	142	3901
1978	3114	992	4354

on its own, many of the objectives can, in fact, be in conflict with each other.

Some of the important controls exercised by the government include requiring mills to obtain a licence in order to expand capacity or establish new mills; controls on the production pattern of yarn and cloth; alternative periods of price controls on output; differential tariffs on the output of the decentralized and mill sectors, in favour of the decentralized sector; and higher tariffs on the production of finer yarn, cloth, and man-made fibres. The government also licences all imports, provides financial incentives for exports, and reviews all proposals for foreign equity or technical collaboration.

Technological and Structural Changes in the Textile Industry

Raw Materials

Although the availability of large domestic supplies of cotton provides an advantage to the Indian textile industry, it is also a major cause of some of the weaknesses within the industry. The varieties of cotton grown in India have a shorter fibre length and are coarser than many of the world's major cottons. The staple length of cotton is closely associated with the strength and fineness of the yarn that can be spun from it and it also affects the rate of yarn production. Efforts to introduce strains of cotton to India to develop longer staple cottons are summarized in Table 6.

Table 7 indicates that the trend of improving the staple length of Indian cotton has continued. A notable advance in this field has been the recent introduction of several superior long staple cotton strains that have excellent properties and staple lengths from 30–33 mm.

Before 1947, the technological problem was only concerned with improvement of fibre length

Table 6. Cotton production (× 10^3 bales)[a]

Year	Staple length (22 mm and above)	Staple length (22 mm and below)	Total	Percentage 22 mm and above
1922–27	1622	3827	5449	30
1927–32	1327	3879	5206	25
1932–37	1650	3665	5315	31
1937–42	2117	3480	5597	38
1942–47	2649	1478	4127	64

[a]Bales of 400 lb (182 kg) each.

Table 7. Cotton production by staple length (× 10^6 kg).

Year	≥27 mm	24.5–26 mm	22–24 mm	20–21.5 mm	0–19 mm
1965	25	176	357	165	136
1970	28	239	439	110	130
1975	322	136	521	91	147
1978	299	107	547	141	112

and quality and little attention was paid to developing varieties that would produce higher yields. After 1947, when a large part of the cotton-growing areas became part of Pakistan, leading to a shortage in domestic supplies of the order of 40%, research emphasis began to be placed on developing higher yielding varieties and improving farm management practices. Thus, yields began to increase after this time.

The supply of raw cotton has been a problem to the Indian textile industry in two ways. Firstly, because it is an agricultural crop, grown largely in unirrigated regions, there are wide fluctuations in the production and price of cotton depending upon rainfall. As mentioned earlier, cotton was largely an export commodity in the early years and most of the Indian textile mill owners started out as cotton traders. The importance of arranging adequate supplies of good cotton, the possibilities of large profits as a result of accurate judgements of cotton prices, and the origin of mill owners in cotton trade have all led to the emphasis placed on the trading activity of mill operations and the subsequent neglect of matters of a technical nature.

The other problem created by a large domestic cotton economy is the reluctance of the government to encourage the man-made fibre industry for fear of affecting employment and wages obtained in cotton farming. The man-made fibre industry has been restricted by the government through limited numbers of licences, with each licensee allowed to produce only a small quantity, and by the imposition of high tariffs on man-made fibres.

Spinning and Weaving

As indicated in Table 2, there has been a fourfold increase in the number of spinning mills between 1948 and 1978. The number of spindles within these units has also increased by almost five times. Of the new mills, 56 have been installed within the cooperative sector since 1956, accounting for 1.2 million installed spindles or 15% of the capacity of spinning units.

The number of spindles in composite mills has

also increased between 1948 and 1978 (AIFCOSPIN 1979). The total number of composite mills and number of looms installed, however, increased only marginally. The notable change during the period 1956 to the present was the replacement of ordinary looms with automatic looms, which increased from 12 000 to over 38 000.

These changes are in keeping with the policy adopted by the Government of India to freeze the weaving capacity of the mill sector but at the same time they bear in mind the age of existing machinery and the need for improved technology in the export market and, therefore, allow mills to replace older machinery. Thus, the supply of cloth from the mill sector has increased only to the extent that the newer looms have higher production capacities than the older looms.

Some of the major technical changes in spinning and weaving are discussed by Rath (1979) and Desai (this volume). Basically, there has been little change in the principles of the processes through which fibre is transformed into yarn and cloth. The main technological changes have been design changes allowing each process to be completed at greater speeds, shortening the number of stages of machinery, some improvement in the treatment of the fibre in the different stages, and improvement in the quality of the product.

In spinning, technological changes have widened the gap between machine spinning and hand wheels by many orders of magnitude. The speed of a modern ring spindle is 16 000–18 000 rpm and is likely to increase to 25 000 rpm in the future. The maximum speed of a spinning wheel, on the other hand, is only 1000–1500 rpm. In terms of production, a simple spindle and whorl will produce approximately 1 kg of 20s count yarn in 150 h. The cost of production of 1 kg of 16s count yarn in a spinning mill in 1979 ranged between Rs4.10 and Rs5.20 (AIFCOSPIN 1979). If this entire cost of conversion is paid as wages for handspinning, it amounts to Rs0.16–Rs0.20 for an 8-h day (minimum legal wage rates for agricultural labour range from Rs3–Rs8 per day). It is for this reason that although large subsidies are provided by the government for handspinning it accounts for a negligible fraction of the yarn produced.

There are a number of curiosities in the policies of handspinning production and in attempts at improving the technology. At various times, newly developed multiple-spindle hand-operated wheels are announced as a breakthrough in the direction of a more appropriate technology but without much success because the increased capital cost is not justified by the increase in the rate of production. It is strange that in this particular case of technological development there has been no attempt to evolve a design from the multiple-spindle spinning jenny that, with 80–100 spindles, was in use in Britain in the earlier decades of this century.

In contrast with the technological change in spinning, the technological change in weaving has been less spectacular. The operating speed of a handloom is 50–100 picks/min. The speed of most of the power-driven looms, which are of an older vintage and are prevalent in India, is about 130–210 picks/min. In the latest generation of weaving machines available in the world, the speed has increased to 500–600 picks/min or a weft insertion rate of up to 1000 m/min. Thus, although the production rates in weaving are rising sharply and may lead to similar developments as in spinning, until recently, the differences between handlooms and power-driven looms have not been wide enough to eliminate handlooms.

Until 1950, cloth production in India was divided between the handloom weavers and the mill sector. Table 8 indicates the consumption of yarn by the handloom and mill sectors.

Initially, the handloom sector lost ground to the mills sector but finally found certain types of production, namely coarse cloth and cloth of intricate woven designs and small production lots, in which it had a competitive advantage over the mills.

In 1935, the number of looms in the mill sector reached 200 000 and has remained at this level since that time. At first, the loomage remained static in the mill sector between 1935 and 1950 due to competition from handlooms, which led to increased intensity of machine operation through greater use of second- and third-shift operations.

By the beginning of 1950, a few people began weaving cloth on powerlooms in small and scattered clusters. Essentially, these looms were similar to those used in mills and the operations

Table 8. Yarn consumption by mills and handlooms ($\times 10^6$ kg).

Year	Yarn consumption by mills	Yarn consumed by handlooms	Total	Percentage consumed by handlooms
1924–25	209	119	328	36
1929–30	255	126	381	33
1934–35	335	122	457	27
1939–40	399	151	550	27
1940–45	545	205	750	27
1949–50	425	161	586	27

differed only in that the yarn was purchased from the market and the grey cloth was sold by the powerloom sector without further processing.

The government viewed this as a desirable development because it would lead to the handloom weaver being able to increase productivity by slowly switching over to power-operated looms. The government provided cash and other assistance and planned a phased program for the growth of powerlooms. It also established higher tariffs on mill sector production to provide a degree of protection to the decentralized sector. From 1950 onward, there was spectacular growth in the number of powerlooms. At all times there were more applications for powerloom allotment than planned for by the government, leading to a large growth in unauthorized powerlooms. It was found that powerlooms were also affecting production by handlooms; thus, a three-tier tariff structure had developed.

Government policy has been to encourage the production of cloth in the decentralized sector because it is more labour intensive. Within the overall framework of this encouragement, policies have attempted to favour the handloom over the powerloom sector.

Implementation of this policy goal has been attempted through three different instruments. On the one hand, additional looms are not allowed in the mill sector. At the same time, government has imposed certain duties on all yarn and fabric produced within the country. These duties are structured to tax, at increasing rates, finer yarn and cloth over coarser varieties and also to tax production of the mill sector at higher rates than for powerlooms and the production of powerlooms at higher rates than for handloom fabrics. Thus, these excise duties, although meant for revenue purposes, are also designed to provide incentives for more labour-intensive technology.

The Textile Commissioner's office also maintains control over looms in the decentralized sector: all handlooms must be registered and the Textile Commissioner's office must specifically approve and licence the installation of all powerlooms. Because of the possible adverse affect on the handloom sector, only a limited number of licences are given to increase the number of powerlooms.

It is apparent that the freeze on mill loomage has created a gap between demand and supply, which handloom weavers are unable to meet. The structure of duties on fabrics, which favours powerlooms in the decentralized sector, favours the decentralized sector even more if the cloth can be shown to have been produced on a handloom. Thus, although the decentralized sector has increased its weaving output considerably over the past 30 years and the number of powerlooms has also increased, to an estimated 211 000 in 1978, the question of changes in output between the handloom and powerloom sectors needs to be examined carefully.

The production of cloth in the decentralized sector rose rapidly after 1950. It doubled between 1950 and 1960 and almost doubled again in the next decade. In order to estimate the shares of the powerloom and handloom sectors in this production, a number of indirect methods must be used.

The procedure used for official estimates is to take the total free sales of yarn as the amount of yarn used in the decentralized sector. Of this, part of the yarn is packed in cones of 1 kg and the remainder in hanks of 840 yards (768 m). It is assumed that because the handloom weaver cannot use the long lengths of yarn in the cone package (for instance, 1 kg of 10s count yarn will have 18 480 yards (16 898 m) of yarn and proportionately more for higher counts), all the yarn packed in cones is used by the powerloom weaver. Similarly, because the powerloom weaver prefers longer yarn lengths and must use cone yarn for technical reasons, it is assumed that all hank yarn is consumed by handlooms.

The response by the mill sector to the increased competition from the decentralized sector was to concentrate on increased capacity utilization together with increased emphasis on product sophistication. Between 1950 and 1960 textile mills invested heavily in processing equipment. Table 9 indicates the productivity trend in 20 textile mills listed in the Bombay Stock Exchange.

Table 9 shows that there is an increase in the productivity of spindles, which is due to both increased capacity utilization and modernization of spinning equipment. There is also an increased productivity of looms, largely due to increased utilization. As one would expect, however, with the increase in the number of processing stages, the number of workers increases without any corresponding increase in production rate and, thus, the productivity per worker decreases. This pattern, within composite mills, is further confirmed by the steady increase in the ratio of bleached, dyed, and printed fabrics to the grey

Table 9. Selected ratios in composite mills.

	1950	1960	1965
Cotton consumed (kg spindle)	50.4	53.3	55.10
Cotton consumed (kg loom)	2206	2538	2816
Cotton consumed (kg worker)	1188	794	840

and unbleached fabrics produced in the mill sector.

The period 1955–1965 accounts for almost all of the technical collaboration agreements signed by textile mills. Most of these agreements were signed by the leading textile mills that had built up a brand-name product in the market. All of the agreements were made with four or five companies in the United States, United Kingdom, Switzerland, and Germany and their purpose was to improve the finish and appearance of the fabrics.

Many of the textile mills that had been supplying less sophisticated, rural markets with coarse, unbleached cloth began to be pressured by growing powerloom production, on the one hand, producing cheap cloth and by mills that had invested in improving their product. In 1965, due to a shortage of cotton supplies, increased prices for the raw material finally forced large

Table 10. Spindle productivity in India.

Year	No. of installed spindles ($\times 10^6$)	Cotton yarn production ($\times 10^6$ kg)	Production (unadjusted) (kg spindle)	Production (adjusted) (kg spindle)
1925	8.51	328	38.54	15.53
1930	9.12	381	41.77	18.07
1935	9.69	457	47.16	25.27
1940	10.00	550	55.00	32.40
1945	10.24	750	73.24	38.27
1950	10.54	532	50.47	34.76
1955	11.96	732	61.20	
1960	13.55	787	58.08	42.39
1965	15.43	939	60.85	45.93
1970	17.67	965	54.61	39.03
1975	18.86	990	52.49	42.12
1978	20.09	912	45.39	35.17

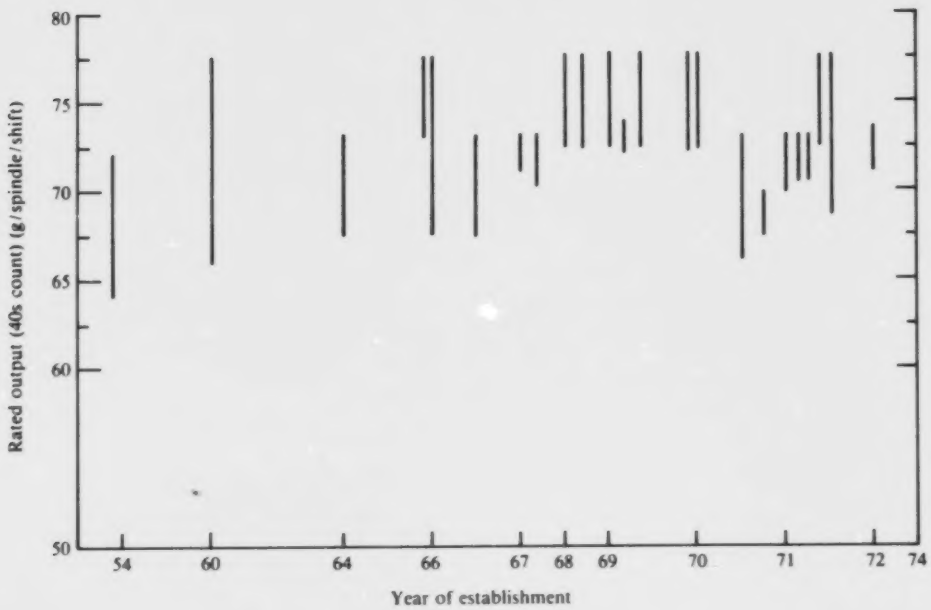

Fig. 1. Change in machine production rates from 1950–1974.

numbers of mills, which had not modernized, into bankruptcy. As a result, the government took control of 104 mills that had closed down or were in difficulty between 1965 and 1970, under the auspices of a new state-owned corporation, the National Textile Corporation.

Productivity Changes in Spinning

Table 10 shows spindle productivity within India. The sharp drop in 1950 is due to a shortage of raw cotton and underutilization of spindles. The subsequent trend, however, is inexplicable, with the advances in production rate of each succeeding generation of ring frames. The answer lies in the changing pattern of production of yarn by the spinning mills. From 1925 onward, with the increasing availability of longer staple cotton and the demand for finer yarn, there has been a shift in the production pattern of yarn toward finer counts and although the spindle is able to produce 194 g shift in 20s count, it produces only 77 g shift in 40s count and 30 g shift in 80s count (SITRA 1975). The last column of Table 10 provides the trend in productivity if the entire production of the spinning mills is adjusted to a standard 40s count.

Structure of Technical Efficiency in Spinning Mills

Figure 1 shows the range of production rates for a group of mills. The figure indicates that the rated speed of production of ring frames ranged from 64 77.5 g spindle shift between the oldest unit established in 1954 and the newest in 1974. Because the 1954 unit may have increased the capacity of the ring frames by modernization, it can be said that technological change has been at least 13.5 g spindle shift (21%) over the 20-year period. The range within each mill between the minimum and maximum rates of production per spindle depends upon the subsequent expansion and modernization program carried out within the mill.

Figure 2 indicates the efficiency of the use of capital and labour inputs by mills using the

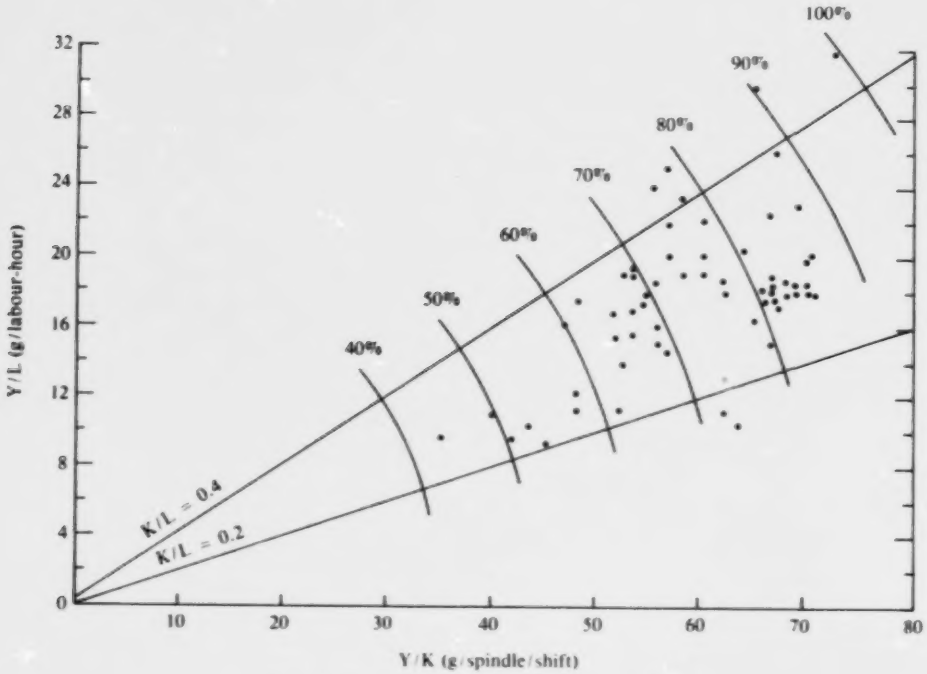

Fig. 2. Structural efficiency of cooperative mills.

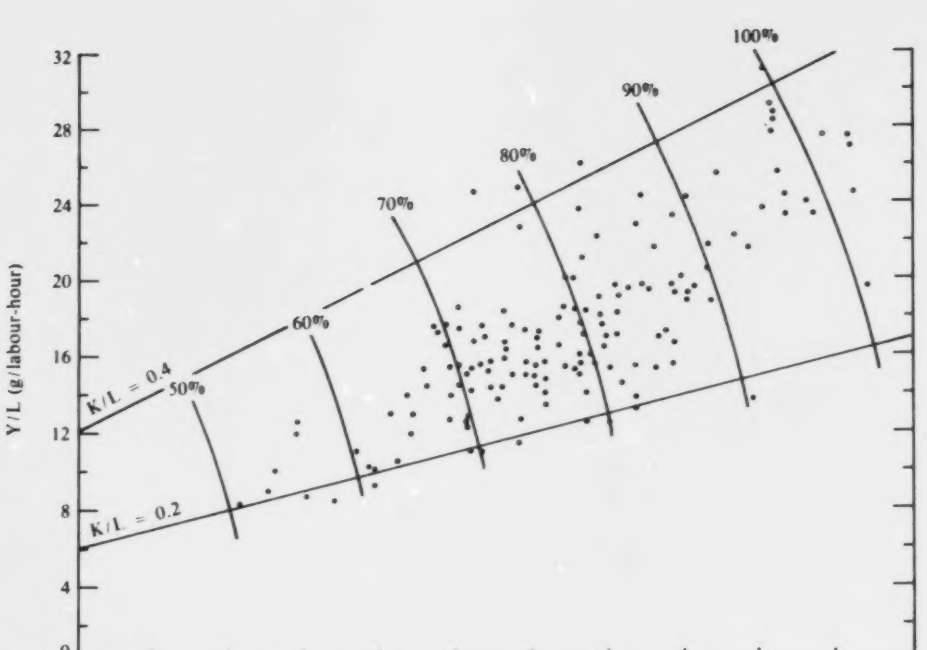

Fig. 3. Structural efficiency at spinning mills.

concept of the Farrell measure of efficiency (Farrell 1957). The approach suggested by Farrell is to estimate and construct a frontier efficiency curve applicable to the sector based on the data. The frontier efficiency may then be taken to be 100% and the efficiency of input use of individual firms can be calculated to be the ratio of the radial distance of the individual firm from the origin to the distance of the frontier efficiency curve from the origin along the same ray. In the present analysis, for simplicity, the frontier efficiency curve has been assumed to be the arc of a circle with the origin as its centre passing through the coordinates of the most efficient firm(s).

The first interesting fact that emerges from the data is the very small range of substitution between capital and labour. All of the points in Fig. 2 are within the range $0.2 = (K/L) \leq 0.4$, where $K/L = (Y/L)/(Y/K)$ and, within this range, the values of Y/L and Y/K are highly correlated with each other. (In these equations, Y = output, K = capital, and L = labour.)

The narrow range of K/L within which all of the observed points are seen to lie indicates that within the present range of techniques in use in this sector there is only a small range of efficient substitution between capital and labour. When the range of substitution between K and L is small, this implies a relatively standardized allocation of labour to capital. This is the reason for the high correlation between Y/K and Y/L; i.e., a mill that is efficient in utilizing capital input has good management that uses appropriate labour and, hence, also makes efficient use of its labour inputs. This applies in reverse as well. A mill that has higher labour is not able to substitute labour for capital. Thus, both efficiencies are low.

In Fig. 3, the same approach was used with a sample of 146 spinning units. The larger sample includes mills in the private sector and has a different age composition than the sample used in Fig. 2. In this sample, the range of K/L for over 98% of the units is between 0.2 and 0.4. The frontier efficiency of both samples is almost identical.

Further comparisons between the two samples

indicate that 31 and 14% of the mills in Fig. 3 lie within the 80–90 and 90–100% efficiency ranges, respectively, and 18.9 and 3.7% of the units in Fig. 2 lie within these respective ranges. These results indicate a much poorer distribution of efficiency in the cooperative sector than in the sample of spinning units.

Another fact that emerges from Figs. 2 and 3 is that mills that have an efficiency of over 90% also have a higher K/L ratio. The mills with efficiency equal to 90%, in both cases, have a K/L range of $0.3 \leq K/L \leq 0.4$. This limited information suggests that the higher K/L ratios relate to newer mills. Thus, the trend in technology is toward a further narrowing of substitutability of capital and labour, and also points to a shift toward a higher capital–labour ratio in the sector.

Further analysis of the 53 units in Fig. 2 looked at the question of whether or not the unit that achieved high technical efficiency also achieved financial success. It was found that financial performance and technical performance are highly correlated. Thus, technical efficiency is the most important determinant of financial performance. To determine what factors contribute to technical efficiency the age, rated production capacity, and location of these cooperative mills were investigated.

It can be argued that because there has been continuous technological change in the technology embodied in spinning machinery, units that were established earlier would be technologically backward and, hence, less efficient. Conversely, newer units would be more efficient. This hypothesis could not be proved; perhaps because most of the units were started between the mid-1960s and early 1970s, leading to small divergencies in technology. These differences have been further obscured through expansion and modernization programs. It may be noted, however, that the most efficient unit studied was also the most modern.

With regard to rated production capacity, it was found that mills with higher technical efficiency and superior financial performance tended to have newer machinery (or older machinery that had been upgraded through modernization programs), whereas those mills with poorer performances tended to have older machinery. This indicates that although modern machinery may not provide sufficient conditions for success, it is most likely to be a necessary condition.

The tendency of mills from Tamil Nadu to cluster together leads one to suspect that a relationship exists between technical efficiency and the location of the unit. Tamil Nadu and Maharashtra are the only two states having a sufficient number of units to test for locational influence. Although the results for Maharashtra are inconclusive, Tamil Nadu is significantly overrepresented by mills that earned a net profit. The superior performance of the Tamil Nadu mills may be due to their location within an area where superior grades of Indian cotton are grown. It may also be due to the improved technological service received from the South India Textile Research Association (SITRA), located in Tamil Nadu, leading to improved diffusion of best-practice technology among the Tamil Nadu mills. This is an important implication for policy purposes and needs to be examined further.

It may be stated that the average efficiency of the 53 mills studied is only approximately 65% of the best-practice efficiency achievable. There is considerable scope for improvement, with attendant economic and financial benefits. Before one can arrive at policies to achieve such improvements, however, it would be necessary to carry out an analysis of the structural efficiency of the same group of mills over time to isolate further the effects of new technology and of diffusion of operational know-how.

Sources of Technical Change

In the spinning, weaving, and processing of textiles, innovations do not normally originate from within the textile industry. The major sources of technical change have been from the chemical industry and machinery manufacturers. The chemical industry has developed new man-made fibres, the most important being rayon, nylon, polyester, and acrylic fibres, and a number of new dyes. The machinery manufacturers have provided new machinery that is faster, more efficient, and provides a product of higher quality.

The major innovations from machinery manufacturers have come from a small number of firms located in Europe, Germany, Switzerland, England, and Czechoslovakia and a few firms in United States and Japan (Desai, this volume). The innovations have originated due to the competitive forces operating on these specialized machinery manufacturers and the needs of users in Europe, United States, and Japan.

Indian manufacturers of textile machinery have exhibited little evidence of innovative activity. (For a description of the origins of Indian machinery manufacturers see Desai (this volume).) The entire range of items manufactured for textile machinery is based on a formal transfer of know-how through collaboration agree-

ments with foreign manufacturers. The collaboration agreements show a similar trend as in other Indian industries, i.e., the earliest collaboration was with a leading British machinery manufacturer, followed by gradual diversification to sources in Switzerland, Germany, United States, and Japan. The import of machinery followed a similar pattern.

Almost all textile machinery items manufactured in India are based on designs developed abroad. Some of the more simple and older machinery is copied from old imported models, without formal licencing provisions. The technology transfer in the textile machinery sector has been through licencing agreements, although there are a small number of cases with equity participation. The terms of these agreements are quite similar and in most cases the foreign manufacturer provides the licences, drawings, and permission to manufacture a specific item. Usually, the period is for 10 years and the royalties are set at 4–5% of the sales value of the machinery, less the import content.

The pattern of technology acquisition has been cyclic. Initially, in the late 1940s and early 1950s, when the textile machinery manufacturer began in India, there were a number of collaboration agreements. The number of agreements remained at a low level until rising sharply between 1960 and 1965. By this time, the design of machines acquired more than a decade ago had become outdated and new designs were needed. The increase in the number of collaborations was also caused by increasing import restrictions due to foreign exchange shortages, which provided opportunities for import substitution in more machinery items. Furthermore, the licences allowed the manufacturers to import parts, which was profitable (Desai, this volume). The number of collaborations again decreased between 1966 and the early 1970s because most major items of machinery had been covered. At this time, the government reduced the number of foreign collaborations and the textile industry entered into a period of slump. The pattern repeated itself during the mid-1970s, again due to the demand on the machinery manufacturers to upgrade designs to new international standards, resulting in another increase in the number of collaborations.

A documented reason Indian firms sought foreign collaboration was the lack of an adequate technical base within local firms to carry out design and development activities. It should be stressed that the technology of machinery manufacturing can be acquired relatively easily by a firm with sufficient engineering skills. Any new development is quickly diffused through journals, meetings, and trade fairs. The principles of new machinery development cannot be kept secret once in use and patent protection is rarely sufficient to prevent competitors from achieving the same results through partial design modifications. The level of engineering skills available within Indian firms, however, is insufficient for them to adopt a policy of competitive imitation. Furthermore, Indian firms are eager to offer machines with the design and name of leading foreign manufacturers because it helps in their market efforts. At the same time, given the existence of a number of manufacturers for any given piece of equipment, it has not been difficult for the Indian firms to find suitable partners.

The process of technology transfer has allowed Indian firms to be able to replicate equipment. Thus, the machinery manufactured in India is almost identical to similar vintage machinery manufactured abroad and with lower labour costs it is 20–50% cheaper than the machinery of foreign firms.

It is possible that, given complete worldwide standardization of textile machinery, there are large economies of scale in the research and development efforts of the textile machinery industry. Thus, the policy of periodic technology purchase by Indian firms may be most cost effective when domestic machine-building capacity is small. Even with the large increase in production of the machinery sector over the last 30 years, expenditures on research and development remain at approximately 0.5%, in comparison with 3–5% for foreign technology suppliers.

Although the industry as a whole appears to be satisfied with being technology dependent, there are individual firms that devote considerable resources to research and development and have developed an open-end spinning machine. It is claimed that the locally prevailing costs of capital and labour have been considered in the design of the machine, which is supposed to be simpler, cheaper, and less automated than comparable European designs.

Man-Made Fibres and Filament

In this industry, all of the rayon, nylon, and polyester units were originally established with the help of foreign collaboration. Of the units in this sector, there is only one company with majority equity held by the foreign collaborator, in 7 units foreign financial participation is below 50%, and in another 10 units the collaboration is purely technical. The role of the foreign participants has usually included the designing, erection, commissioning, and supplying of plants and

equipment. Due to government policy, all of the units, with the exception of Gwalior Rayon, have plant capacities well below the international norms prevailing for the industry, which has resulted in small, high-cost units with little capacity for independent technological development.

The size of Gwalior Rayon is unusual in this sector. It has devoted considerable resources to successfully develop and patent a number of innovations, one of which is the successful use of a number of domestic species of timber for the production of rayon grade pulp. Its operations are highly integrated and include the fabrication and supply of complete rayon plants, production pulp, rayon filament, and staple fibre and fabrics. It now acts as a source for technology and has supplied the complete plant and know-how to some new units within the country and has also been the collaborator for a number of plants in Southeast Asia, where it participates both financially and technically and has been responsible for the designing, supplying, erection, and commissioning of complete plants.

Summary and Conclusions

The major thrusts of government policy in India affecting the textile industry have been to increase or protect employment within the industry in the face of technological developments that are operating in the opposite direction. In spite of a number of government interventions, handspinning is obsolete and handweaving is stagnant. The trends in the development of weaving technology can affect the powerloom industry in a similar fashion in the future.

The desires of the government to protect employment are in conflict with the desires to improve export earnings from the textile sector. The export markets increasingly require large runs of fault-free cloth of a quality that can only be produced through the use of superior grades of cotton, larger supplies of man-made fibres, and the best spinning and weaving machinery currently available, which are more capital intensive.

The major policy instruments used by the government are legal constraints and financial levies and incentives. There have been almost no attempts to actively intervene in the nature and process of technological change, through research funds and programs, in the area of textile machinery.

The objectives of employment protection, prevention of monopolies, and a desire to restrict the consumption of "luxury" fabrics has led to a situation of uneconomic production of cellulosic and synthetic fibres. At the same time, the protected market has allowed large profits for most units. All of these factors combine to preclude an innovative role for the sector.

In the production of yarn and fabric, the attempt has been to increase the production of coarse yarn and cloth through the imposition of higher duties on finer counts. This has gone against the demand preference and trend in cotton supplies. This policy has not resulted in a shift in the composition of the output but only a shift in the production of finer fabrics to the decentralized powerloom sector, which by its nature is more difficult to monitor and, therefore, able to evade the impact of higher duties.

The spinning and weaving industry as a whole is not an innovator of technology but receives technological innovations embodied in machinery and raw materials. The major technical and economic criteria upon which this part of the industry should be judged is on its efficiency of resource utilization, where the level of efficiency of the industry is quite low. The utilization of machinery has historically been very low, with second- and third-shift operations becoming prevalent only in the 1950s. Even now, the average working day is only 22.5 h instead of 24 h. The average number of days worked is only 300 per year. This is in contrast with the 24-h, 365-day operation of a few mills in India and the standard practice in Hong Kong. In spinning and weaving, labour productivity per shift is higher in Hong Kong by approximately two and three times, respectively, even though the machinery is similar. After discounting machine utilization, the output per spindle per year in Hong Kong for 20s count is 196 kg and in India it is approximately 160 kg, almost 20% less (Indian Institute of Management 1976).

Part of the difference arises from the poorer quality of Indian cotton compared with the world standard. Another problem arises from poor management of textile mills, particularly the lack of adequate attention to proper settings, operating conditions, and maintenance of textile machinery. One survey by Ahmedabad Textile Industry Research Association (ATIRA) found that approximately 60–75% of the mills had machinery in poorer condition than the standard settings and maintenance prescribed. The large range between the efficiency of mills may be attributed to poor management and structural conditions within the Indian political economy, which allows it to survive.

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Comments: Suck-chul Yoon

The report from India is just an interim report. The research project, according to the author, started last November. Comments in an organized and systematic manner, therefore, are not possible at this stage.

The report does not state the objective or goal of the research project and does not mention anything about the methodology adopted. The lack of this information renders commenting on the report rather difficult.

The first half of the report is devoted to describing background history, facts, and data on the Indian textile industry sector. Some of the information could be useful and relevant to the future development of the study.

Throughout the report, measurements of technical performance were made only in terms of output quantity. The study tries to analyze the technological changes in the Indian textile industry over a time span of a quarter of a century. Over a time span of this duration, the quality change, whatever it may be, could be too significant to be neglected, which the report did. It is suggested that: (1) output quantity/raw material used or (2) number of defects per unit quantity of output be used as indicators to represent quality change.

The study adopted the concept of the Farrell measure of efficiency to draw some conclusions regarding technical change within the industry. However, Farrell efficiency is based upon the concept of frontier efficiency at a fixed time. Hence, it could be a good measure for efficiency distribution in the industrial sector, but to draw a conclusion on technical change over time using the Farrell efficiency concept is not appropriate because the frontier efficiency changes every year.

The conclusion that firms that achieve high technical performance also achieve financial success could be valid in an advanced country where financial resources are easily accessible but in most developing countries import of foreign techniques and adoption of modernization or expansion programs are only possible when a firm has achieved a certain degree of financial strength. Hence, instead of the assumed hypothesis, the reverse may be more accurate, i.e., financially strong firms are likely to achieve technical efficiency to a higher degree.

Technology and Market Structure Under Government Regulation: A Case Study of the Indian Textile Industry

Ashok V. Desai[1]

Although the small market limits the number of competitors and the intensity of competition within most Indian industries, the textile industry remains an exception. It was, perhaps, more competitive 30 years ago, when a large number of mills produced undifferentiated yarn or grey cloth and sold it at prices over which they had little control. Today, there is greater product differentiation, but the number of competitors is greater and among them are groups (e.g., powerlooms) between which collusion is possible.

The intensity of competition is not reflected in the speed of adoption of innovations or their diffusion. New technology, embodied in equipment, has been imported from abroad after considerable lags, although the lags have been shorter when the rate of investment has been high. The range of technologies in use at any point in time has also been great, largely because new investment has tended to go into new enterprises and old enterprises have been sheltered from competition by low depreciation costs.

In general, a number of new elements were introduced during the postwar period. (1) With the separation of Pakistan, India lost some prime cotton-growing areas, a shortage of foreign exchange limited cotton imports, and the size and quality of domestic cotton output began to influence the growth of the textile industry, which has only recently been modified by the supply of man-made fibres. (2) Quantitative import restrictions led to the growth of a diversified textile machinery industry, which made equipment more widely and easily available than was the case prior to the 1950s. (3) The government discriminated against various segments of the industry both by fiscal means and through its control of productive capacity. The discrimination was against mills, which, as a result, faced more intense competition. The purpose of this paper is to review the influence of these forces on the technology and market structure of the textile industry.

It should be noted that virtually all of the available data refer to the mill sector and almost none to the small-scale sector. Hence, conclusions made about the latter are necessarily in the way of inferences, although they have a basis insofar as the small-scale sector buys its yarn from the mills. Another important point is that it is treacherous, in India, to judge the success of a firm or industry from its rate of profit. The taxation of declared profits creates a strong incentive to take profits in undeclared forms. There are, undoubtedly, some large corporations that are fair to shareholders and have a strong enough competitive position to make high declared profits even after tax, but in companies and other types of firms controlled by a family or a small group of people, profits are, to a great extent, distributed without being called profits. In the textile industry the rate of profit is doubly misleading because its capital equipment is old and, hence, valued at extremely low historical costs. If it were valued at replacement costs, a large part of the industry would be operating at a loss. Hence, the success of firms and groups is judged on the rate of growth of sales, based on the assumption that a firm would not be expanding if its owners found it unprofitable to do so.

Cotton Textile Technology

Cotton textile technology has three essential stages: cotton preparation, spinning, and weaving. Preparation entails cleaning, straightening, and aligning the fibres; spinning involves drawing out and twisting the fibres into a thread with

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some tensile strength; and weaving consists of stretching the threads and arranging them into a dense grid, which constitutes cloth.

In the manual form, which can still be observed in khadi (handspun cloth) production in India, the preparation of cotton consists of three stages. Firstly, the cotton is ginned, i.e., cotton received from the field is passed between rollers that are too close together to allow the seeds to pass; in this way, the lint is separated from the seeds. The lint is then blown: a taut string passing through the cotton is beaten and as it springs up it throws up cotton tufts that open out and shed dust and grit. In the third stage, the clean cotton is passed through rollers with teeth or knives that stretch out the fibres in a single direction, producing a pad of more or less even thickness. This pad, or lap, is then rolled into slivers.

All of these stages are present in the mechanized version of the technology as well. Blowing is accomplished using air jets but apart from that machine operations duplicate the manual processes. The productivity of labour and equipment in the succeeding process, spinning, depends upon the quality of the sliver (or roving, as it is called in the mechanized version). Hence, as the speed of spinning increases, the preparatory processes become more elaborate and better controlled.

In handspinning, the spinner draws out the sliver with one hand to thin it down and turns the spindle with the other to give the emerging yarn a twist. In the next movement, the yarn is wound onto the spindle. By varying the relative rates of drawing and twisting, the spinner can vary the thickness of the yarn: a skilled spinner can spin thinner and more even yarn with fewer breaks. Thus, the spinner's skill can compensate, to some extent, for the quality of the cotton as well as the preparation. In mechanized spinning, the twisting of fibre into yarn as well as its winding onto the spindle are simultaneous operations carried out at a constant speed. Hence, the roving being fed into the ring frame must be more standardized and homogenized than the sliver used on the spinning wheel. Open-end spinning machines, which have been introduced abroad within the last 15 years and which operate at higher speeds than ring frames, require even better processed cotton; in particular, they require cleaner raw material as well as a dust-free environment.

In handweaving, the weaver uses one hand for shedding, i.e., for raising and lowering the strands of yarn running forward (the warp), and the other for picking, or moving the shuttle that carries the crosswise strand (the weft) across the warp. A powerloom performs the same operations mechanically. In an automatic loom the shuttles are replaced mechanically when they run out of yarn, so that an operator, whose remaining task is to mend yarn breaks, can look after more looms. In shuttleless looms, the shuttle, which is relatively heavy (≈ 50 g), is replaced by either a lighter projectile, a gripper or a rapier, which picks up the yarn at one end and drops it at the other, or by a jet of air or water. The energy consumption is, thereby, reduced and the speed increased.

Manual spinning and weaving make different demands upon workers. The process of twisting fibre to produce yarn does not require strength; thus spinning was traditionally carried out by women. Spinning wheels are light, and workers' strength does not set a limit on their output (although this may not be true of the new multispindle devices such as the Ambar Charkha). The rate of manual spinning is limited by the worker's speed in turning the wheel and skill in controlling the twist and evenness of the yarn. The moving of the shuttle on a loom, on the other hand, is physically exhausting, thus hand weaving is generally carried out by men.

The mechanization of the two processes also poses very different problems. Twisting of fibre requires a rotary motion, which is easily mechanized by means of shafts connected to prime movers. Moving of the shuttle, on the other hand, is a lateral motion and, although rotary power can be and is converted into lateral motion, there is loss of power in the process, and the process cannot be speeded up as much as spinning by mechanization or as long as the powerloom is a close imitation of the handloom. As a result, handweaving survived much longer in all countries than handspinning and productivity in mechanized weaving still continues to be lower (in terms of yarn woven per man-hour) than in spinning (in terms of yarn output per man-hour).

In India, handspinning died out, for all practical purposes, by World War I, if not before. Despite its promotion by M.K. Gandhi and subsidization by the government after independence, it remains quantitatively insignificant. Handweaving, however, never died out, and continues today, although it probably does not account for more than 25% of current yarn consumption.

Government Policy

The government has discriminated against textile mills for over 25 years on the grounds that more labour-intensive technology than is being used is available and its usage should be

encouraged. The discrimination takes a number of forms.

(1) The government subsidized the Khadi and Village Industries Commission, which organizes the production and sale of handspun and handwoven cloth. It also buys khadi for the uniforms of its lower paid employees.

(2) In 1956, the government banned the installation of new looms by mills. Since that time, mills have been allowed to purchase looms only for replacement or for export production.

(3) The government charges excise duties on the mills' output of yarn and cloth. The ban on new looms in mills and the differential excise duties greatly benefited powerlooms set up outside mills to the detriment of handlooms. Since 1976, however, excise duties have been levied on the processed output of powerlooms as well, although not at such high rates as those placed upon the mills' output.

(4) Between 1965 and 1978 the government required that a certain proportion of mill output should consist of coarse cloth and must be sold below a controlled maximum price. The idea was to subsidize poorer buyers at the expense of the rich. Apart from the losses this scheme imposed upon weaker weaving mills, however, neither handlooms nor mills taken over by the government could face the resulting competition in the market for coarse cloth. As a result, the government now uses the mills that went bankrupt and were subsequently nationalized to make the bulk of cheap cloth for sale, and supplements its supply by purchasing a small quantity of coarse yarn from mills.

(5) The government has used the industrial licencing mechanism to encourage cooperative spinning mills, which are expected to sell their yarn to member weavers.

Spinning

Except for the very small amount of cotton that is handspun, all yarn is made in large-scale textile mills in India. There are two types of mills: those that only spin yarn (spinning mills) and those that weave it as well (composite mills). The latter, as a group, produce more yarn than needed for their own cloth manufacturing and sell the balance in the market. The yarn supplied by spinning and composite mills is bought by handloom and powerloom weavers through traders or through their own cooperatives (Table 1).

Among synthetics, the only yarn that is of much significance is viscose rayon, which is prized by less-affluent women as a substitute for silk and is used in saris and dresses for weddings and ceremonies. The demand for rayon has always been buoyant. Production is profitable, but because there is a domestic shortage of pulpwood, a large proportion of the quantity consumed is imported. Rayon is woven mainly by powerlooms outside textile mills and there is an active market for it.

It has been a standing complaint of the small-scale sector that composite mills meet their own yarn requirements first and sell only the surplus. If this were so, the proportion of yarn sold to the small-scale sector should have fallen whenever there was a yarn shortage, which has not always been the case. Given the differential excise duties, the wage differentials, and the restrictions on technological change in weaving by mills, it appears that the small-scale powerloom sector has enjoyed a competitive edge over the mills (spinning yarn for sale is more profitable than weaving, even for composite mills) and the small-scale sector's complaints of yarn shortage are

Table 1. Cotton yarn supply (thousand tons)

	For cloth production							
	Sales to small-scale sector							
Year	Composite mills	Spinning mills	Total	Self-consumption of composite mills	Total	Nonfabric uses	Exports	Total
1960			246	516	762	12	11	785
1965			337	568	905	16	11	932
1970			406	524	930	15	26	971
1975	105	333	438	513	951	16	3	970
1976	104	345	449	523	972	18	15	1005
1977	96	310	406	411	817	21	12	850
1978	117	332	449	432	881	23	5	909

Sources: Indian Cotton Mills Federation (1976), Textile Commissioner (1980)

Table 2. Spinning capacity utilization, 1950–1978.

Year	Spinning mills			Composite mills			Spindle capacity utilization (%)			
	Number	Spindles (× 10^3)	Average spindles per mill (× 10^3)	Number	Spindles (× 10^3)	Average spindles per mill (× 10^3)	1st shift	2nd shift	3rd shift	Average
1950	94	1860	20	268	8695	32	85.3	75.9	25.4	62.2
1955	116	1768	15	292	10189	35	85.2	79.5	32.1	65.6
1960	186	2931	16	293	10619	36	87.0	85.3	44.8	72.4
1965	253	3941	16	290	11493	40	86.0	86.6	65.2	79.3
1970	366	5463	15	290	12205	42	78.0	78.2	68.4	74.9
1975[a]	330	6539	20	288	12308	43	72.4	73.2	66.7	70.8
1976	330	6884	21	288	12406	43	69.0	69.8	63.8	67.5
1977	338	7404	22	289	12296	43	77.3	78.2	70.9	75.5
1978	357	7680	22	291	12400	43	80.8	81.8	76.4	79.7
1979	370	8160	22	291	12520	43	78.8	79.6	78.2	78.9

[a] The number of spinning mills from 1975 onward excludes waste spinning mills.
Sources: Millowners' Association (1979); Southern India Mills' Association (1980, Tables 11, 19).

only a reflection of the powerlooms' profitability.

Nevertheless, these complaints have evoked a policy response. In contrast to its freeze on the weaving capacity of mills, the government liberally sanctioned the expansion of spinning capacity (Table 2). In sanctioning such capacity it gave preference to spinning mills and particularly to spinning mills started by loom cooperatives, of which there were 54 by 1978 and another 10 under construction (Committee on Controls and Subsidies 1979). The expansion in spindleage, therefore, was accompanied by an increase in the number of mills; the average size of a spinning mill, however, changed little between 1950 and 1979.

This expansion led to competition between three sets of mills: old spinning mills, composite mills, and new mills. New mills installed ring frames of postwar design, which were appreciably faster than the prewar models used in old spinning mills and composite mills.

The old mills met the competition in two ways. Firstly, they increased multiple-shift production: the proportion of spindles in second-shift operation rose from 76% in 1950 to 87% in 1965, whereas the proportion in third-shift operation went up even more sharply from 25% to 65% during the same period. Thus, by 1965 virtually the entire spinning industry was working two shifts, and two-thirds of it was working three shifts. This high level of capacity utilization was not maintained after 1965, however, because the cotton supply could no longer keep pace with the growth of spindles. In addition to the increased capacity of old mills, new mills began to achieve equally high levels of capacity utilization. Due to the ensuing competition, a number of spinning mills closed down or were taken over by the government; there was, however, no decrease in multiple-shift operation.

Secondly, the expansion of spindleage was accompanied by investment in cotton preparations, i.e., blowroom machinery, carding engines, draw frames, speed frames, and doubling frames. Although much of the investment went into new spinning mills, old mills also improved their processes in two ways: they installed new carding engines, including the new Crosrol Varga models to improve the quality of slivers (domestic manufacturers' sales of carding engines were much in excess of those required by new ring frames, approximately three for each ring frame) (Table 3) and they installed high-draft conversion attachments designed to increase the speed of draw frames and ring frames, which raised their capacity by 10–20%.

There was, however, one change that did not occur. Until 1966, India grew very little long-staple cotton; what little was used was imported. New local hybrids then went into cultivation and their output rose so rapidly that they replaced imports and supplied nearly a quarter of the cotton by 1978 (Table 4). With this change in the staple pattern of cotton supply, one would have expected a corresponding change in the count composition of yarns. The yarn output pattern did move toward higher counts, but not nearly as much as the shift in the staple composition would have permitted. Evidently, the new supplies of long-staple cotton were being used to produce medium counts. The reason for this was clearly related to the demand pattern for cloth.

Apart from its implications for capital utilization, multiple-shift operation enabled mills

Table 3. Output of textile equipment, 1958–1979.

Year	Blow-room lines	Carding engines: Old model	Carding engines: Crosrol Varga	Combers	Draw frames	Speed frames	Doubling frames	Ring frames	High-draft conversion systems: No.	High-draft conversion systems: Rs (× 10^3)
1958		1148			9	28		877	136	4115
1959		763			40	16	7	1077	210	2400
1960	1	1075			47	45	156	1127	287	3157
1961	5	1308			75	70	113	1380	348	5065
1962	10	1501			61	45	115	1571	531	7093
1963	16	1696			52	96	80	1990	526	7469
1964	15	1938			38	49	140	2134	NA	13120
1965	17	1808			16	30	134	2308	1831	29434
1966	16	1809			26	68	174	1507	1240	18542
1967	22	432	148		112	90	97	1256	555	13042
1968	9	172	247		164	44	86	813	570	12788
1969	14	296	465		223	87	154	880	NA	16237
1970	16	381	600		255	132	198	1357	NA	20699
1971	15	317	401		332	129	212	1161	NA	21453
1972	15	171	222	2	297	129	84	885	NA	21607
1973	20	436	46	36	258	125	123	1225	NA	31737
1974 75[a]	31	556	669	60	496	214	98	1795	NA	69337
1975 76	31	532	226	59	480	309	73	1598	NA	51089
1976 77	28	524	455	66	502	407	185	1436	NA	61558
1977 78	33	259	499	41	370	259	249	1356	NA	45997
1978 79	38	372	566	59	572	366	195	1661	NA	93743

NOTE: NA = not available.
[a]Financial years (April–March) from this time onward.
Sources: Textile Machinery Manufacturers' Association (1961; 1965; 1970; 1971; 1975; 1979; 1980).

Table 4. Staple length composition of mills' cotton consumption.

Staple length (mm)	Consumption by weight (thousand tons): 1960	1965	1970	1975	1978	Consumption by percentage: 1960	1965	1970	1975	1978
≥27										
Foreign	178.65	136.62	128.52	33.15	92.82	19.31	11.91	11.21	2.74	8.25
Indian			18.20	249.56	280.50			1.57	20.65	24.94
24.5–26	144.89	154.98	153.34	90.78	115.77	15.66	13.51	13.37	7.51	10.29
22–24	274.03	616.14	430.27	432.14	351.05	29.63	53.72	37.51	35.75	31.22
20–21.5	288.55	174.24	298.01	244.46	163.54	24.71	15.19	25.98	20.23	14.54
≤19	98.66	64.80	118.66	158.61	120.53	10.67	5.65	10.34	13.12	10.72

Sources: Textile Commissioner (1966; 1972); Indian Cotton Mills Federation (1973; 1976); Millowners' Association (1979).

to improve labour productivity in two ways: (1) some of the surplus workers could be transferred to the second and third shifts and (2) because workers were not as readily available for the night shift, lower manning levels were accepted for it (the number of spindles per worker was 79 in the first shift and 117 in the third shift in 1960; by 1979, it had risen to 117 in the first shift and 181 in the third (Textile Commissioner 1962; Southern Indian Mills' Association 1980)).

Weaving

According to the latest figures published by the Textile Commissioner, the number of handlooms covered by cooperatives was 1.4 million in 1969 (Textile Commissioner 1972). Their capacity (estimated at 5 m day, 300 days per year) should be 2.1×10^9 m, or nearly 60% of the small-scale sector's output in that year. However, their capacity utilization is poor, their capital costs are

low, and so are the wages of handloom weavers. As a result, when alternative employment offers better wages, weavers take up outside work. It is doubtful if more than 30% of small-scale production is woven on handlooms.

The important competing groups, therefore, are composite mills and powerlooms in the small-scale sector. This competition has been regulated by the government by means of differential excise duties. Powerlooms were untaxed until 1955, at which time a duty was introduced at rates of Rs25, 75, and 150 per loom on units with 5–24, 24–49, and more than 50 looms respectively. In practice, however, larger units evaded duty by dispersing looms in a number of sites until the exemption given to units with 1–4 looms was removed in 1965 (Millowners' Association 1979). In 1976, this loom duty was replaced by duties on processed cloth from handlooms and powerlooms, which amounted to 30 and 70%, respectively, of the duties paid by mills; handloom cooperatives, however, continued to be exempt (Millowners' Association 1979). In order to evade the duty, however, a great many looms operated without the licence, from the Textile Commissioner, that they required.

Mill production was almost free of excise until 1949; there was only a 25% duty on superfine cloth. In 1949, small revenue duties were imposed on all cloth, which increased with its fineness. In 1953, a punitive duty was imposed on dhotis produced by mills if their output exceeded 60% of the output in the financial year 1953–1954. The discrimination was so strong that mills, for the most part, gave up dhoti production to small-scale industry.

Revenue duties began to rise in 1956, when the government's budgetary demands started increasing in order to finance the Second Five-Year Plan. In 1958, a system was introduced that lasted until 1977, under which the rates increased with the fineness, as well as the degree, of processing. In 1977, this system was replaced by one under which the duty increased with the price of the cloth, except for fine and superfine cloth, which bore the highest duty regardless of its price.

This differential taxation had two effects:

(1) It discouraged the production of finer cloth. Fiscal discrimination explains the fact that the pattern of yarn output did not move toward finer counts nearly as much as the pattern of cotton consumption moved toward long-staple fibres. In the 1970s, spinning mills were producing coarser yarn than necessary with the available cotton because at postduty cloth prices there was not enough demand for fine cloth.

An incidental effect of this shift in the output pattern was that less cloth was produced. Although 1 kg of yarn (of the appropriate count) produces about the same length of superior medium or fine cloth, it produces 50–60% more superfine cloth. Thus, the use of cotton, which could have produced superfine cloth, to make less fine cloth resulted in a commensurate loss of output. If the long-staple fibre, constituting approximately one-quarter of the total consumption by the late 1970s, had been used to make superfine cloth, it would have added 12–15% to aggregate cloth production. This is an overestimate, however, because it is not evident that all the cotton could have produced superfine cloth and because such a large increase in superfine cloth output might not have been absorbed by the market despite the lower prices that lower excise duties would have permitted. The possibility of substitution, on the other hand, makes the demand for varieties of cloth highly price-elastic. It is possible to argue, therefore, that less strongly progressive excise duties would have brought about a better balance between the pattern of cotton supply and the pattern of demand for cloth. This may not be equally true today, however, because, since 1977, the degree of progression has been reduced and the maximum duty on unprocessed cloth is now 15%. The continuing duty on fine and superfine cloth, regardless of its price, is clearly capable of influencing the production pattern in the same way as before 1977. Virtually all fine and superfine cloth is processed further and, therefore, bears additional processing duties.

(2) The duties diverted production to powerlooms, and the diversion was greater in the case of fine fabrics, which were more heavily taxed. It was commonly believed that fine cloth was a preserve of the mill industry and that the small-scale sector concentrated on coarse cloth. In general, the small-scale sector produced a larger proportion of coarse cloth. This is particularly the case with handlooms. The time required on the loom per metre increases with the fineness of the cloth and so, therefore, does the weaving cost per metre. Because handlooms are much slower than powerlooms (50 times slower according to Bruce (1977)), the cost difference between fine and coarse handloom cloth is greater than with powerloom cloth. Because fine cloth takes longer to weave on a handloom, inventory costs are also higher. Although handlooms specialize in coarse cloth (and fabrics with complicated weaving patterns that require longer loom setup times), there is no reason for powerlooms to do so. They are plain looms, but they are no less efficient than plain looms in mills; if anything, they are newer on the average (although mills

have not been allowed to increase their loomage since 1956 and have largely been operating with prewar looms, most of the powerlooms of the small-scale sector were acquired in the 1950s and 1960s). Mills have been allowed to acquire some automatic looms or to replace plain looms with automatic looms, but such acquisitions have been allowed only for exports and are confined to a small number of mills; thus, the overall proportion of automatic looms remains small. Although concentrating on coarse dhotis and saris, powerlooms have increasingly ventured into the production of fine cloth. In 1960, powerlooms consumed about the same quantity of yarn with a count of 41 and above as mills and in 1970 they consumed more than twice as much as consumed by mills. The entire increase in fine yarn output between 1960 and 1970 went to powerlooms (Table 5).

Weaving mills countered the competition of powerlooms in three ways:

(1) They increased the capacity utilization of looms by increasing third-shift operation, which rose from 10% in 1950 to 66% in 1979. Thus, virtually all looms were working two shifts and two-thirds of them three shifts by 1979 (Textile Commissioner 1962: Tables 13, 19). As with spinning, the rise in capacity utilization coincided with and contributed to the increase in the number of looms per worker, which rose from 1.27 in 1960 to 1.86 in 1979.

(2) The mills increased the number of picks per metre of cloth and wove more closely (cf. Mohota 1976), thus weaving stronger and more durable cloth. The metres woven per kilogram decreased throughout the 1960s, more so for fine cloth (Table 6). (Two other possibilities for this decrease, i.e., understatement of output and increase in width, may be ruled out. The incentive for both would be evasion of excise duty, but if output had been understated in metres, it would have been understated in terms of weight also, leaving their ratio unchanged. Also, an increase in breadth would not have reduced the incidence of the duty, whose base was changed from linear to square metres in 1955. Part of the increase in weight (less than 10%), however, is explained by the wider application of preshrinking processes such as mercerizing and Sanforizing.) The resulting impact occurred as a fall in per capita cloth consumption in the early 1970s.

(3) The mills began to process an increasing proportion of their cloth. Preshrinking processes, which were virtually unknown in the 1950s, were applied to over half of the output by 1979 (Table 7). An increasing proportion of the cloth

Table 5. Count composition of yarn consumed.

Count	1960	1965	1970	1975	1976	1977	1978
Self-consumption by weaving mills (thousand tons)							
1–20	216.9	248.0	204.6	177.5	212.7	160.8	177.1
21–30	206.5	224.2	210.8	194.7	179.6	144.5	147.1
31–40	91.6	98.3	106.9	107.1	97.4	81.2	86.0
41 and above	27.2	32.0	38.5	33.7	32.9	24.5	21.4
Deliveries to handlooms and powerlooms (thousand tons)							
1–20	120.3	155.6	177.2	206.0	204.6	161.1	182.7
21–30	49.8	66.9	73.3	65.8	68.2	63.8	67.4
31–40	42.0	54.5	75.0	80.7	91.5	106.8	115.7
41 and above	33.6	59.8	81.1	85.2	84.9	73.6	82.8

Sources: Textile Commissioner (1962; 1973; 1980).

Table 6. Metres per kilogram of mill cloth produced.

	Grade of cloth				
Year	Coarse	Medium	Superior medium	Fine	Superfine
1961	5.19	8.29	10.10	9.41	16.35
1965	4.92	7.98	9.69	8.89	15.10
1970	4.78	7.86	9.18	7.92	14.41
1972	4.72	7.94	8.98	8.12	13.24

Source: Textile Commissioner (1973).

was dyed or printed. Printing used to be, and to a considerable extent still is, a manual process in India, geared to short production runs and often custom-made orders. Mills began to compete with handprinters; in this venture they were helped by the advent of new azo dyes, in attractive colours, and by rotary screen printing machines, which brought flexibility into printing.

Not all cloth mills adopted these innovations. Those that lagged behind were driven into bankruptcy. One hundred and eleven mills, the majority being composite mills, went bankrupt in the late 1960s and early 1970s and were, subsequently, nationalized. Those that improved their technology emerged with a product that was clearly differentiated from that of powerlooms in durability, quality, and finish and that could, therefore, bear the higher duties. Many of these mills started, or expanded, their own retail shop networks, advertised their textiles, and built up a brand image. Weaving mills as a group, however, continued to lose ground. Even the sharp increase in the supply of synthetic fibres after 1975, in whose blending and utilization composite mills had a certain lead, did not reverse the continuing decline in their market share (Table 8).

Textile Machinery and Embodied Technological Change

Textile technology has progressed rapidly since World War II. There have been two major inventions: open-end spinning and shuttleless weaving. Furthermore, all processes have been greatly speeded up. Labour time required per kilogram of yarn has fallen from 10 min in 1959 to 2–3 min on ring frames and 1–2 min on open-end spinners. In weaving, labour productivity has risen from 63 000 weft-metres per hour in 1959 to 383 000 weft-metres per hour. Output of cotton

Table 7. Processing of cloth by mills, 1960–1979.[a]

Process	1960	1965	1970	1975	1979
Total mill output			4238	4267	4155
Bleached	1784	1736	1799	1807	2315
Dyed	750	890	1228	1264	1390
Printed	590	777	1088	1134	1079
Mercerized	63	713	811	744	1187
Sanforized	43	323	430	314	675
Other chemical processes	NA	49	100	76	218
Total cloth processed[b]	3230	4488	5456	5339	6864

[a] All values in million metres.
[b] Total cloth processed exceeds total mill output because some of the cloth undergoes multiple processing.
Sources: Indian Cotton Mills Federation (1976; 1980); Textile Commissioner (1980).

Table 8. Output of cloth by fibre and blend, 1960–1979.[a]

	1960	1965	1970	1975	1979
			Mills' output		
Cotton	4616	4587	4157	4032	3203
Viscose and other synthetics	3	4	1	1	9
Cotton–viscose	NA	NA	17	83	397
Cotton–polyester	NA	NA	53	118	162
Other blends	NA	NA	10	33	383
			Small-scale sector's output		
Cotton	2013	3056	3692	4002	4334
Synthetics[b]	544	866	932	863	NA
Blends	NA	NA	55[c]	166	771

[a] All values in million metres.
[b] Almost entirely viscose rayon.
[c] Estimated from yarn consumption by applying the mill ratio of number of metres to weight.
NA = not available.
Sources: Indian Cotton Mills Federation (1969; 1973); Textile Commissioner (1968; 1972; 1973; 1980).

per card has risen from 8 kg h in 1960 to 80 120 kg h. Drawing frames have increased their speed from 90 m min in 1960 to 600 m min. ring frames from 12 000 rpm to 18 000 rpm, and looms from 40 000 weft-metres per hour to 65 000 weft-metres per hour. Thus, every type of machinery has been speeded up with a consequent saving in labour and space (Hartmann 1980).

This rapid technological change has been engineered by a textile machinery industry with its centre in continental Europe. The open-end spinner was an invention of Investa, a Czechoslovakian firm, whereas the first shuttleless loom was made by Sulzer, a Swiss firm. Swiss and German firms are technological leaders, but the flow of information among the leading firms throughout the world — chiefly German, Swiss, French, and Italian, with a sprinkling of American and Japanese firms — through fairs, meetings, and journals is extremely rapid. There is considerable cross-licencing and imitation, and no invention remains exclusive to the originating firm for long. Most of the firms are small by European standards, production runs are short, quite a few retain an old family tradition of craftsmanship, and most specialize in a limited range of equipment. Large firms, which can set up turnkey textile mills, are scarce.

European firms are located in old textile centres — Saxony, Alsace-Lorraine, Basel, the Rhone valley, Milan — some of which have since declined. They continue to respond to the needs of the local textile industry. The spectacular increases in the speed of new equipment and the labour productivity achievable with it have been a reaction to the loss of manpower by and the rise of wages in the European textile industry during the postwar years. This depressed industry has not been a good customer for machinery, and many of the textile equipment manufacturers have diversified into other types of machinery. They are less specialized in textile machinery now than during the 1960s, and what characterizes them today is their pool of engineering and chemical talents, which are put to use in designing new machinery and processes. Knowledge of this nature has never existed in India, nor does it exist now.

The origin of the Indian textile machinery industry can be found in three types of firms: (1) Repair and service specialists. A small number of firms started as repairers of equipment and graduated to the fabrication of parts and, later, equipment. (2) Stores importers and manufacturers. There are numerous wearing parts of textile machinery that require frequent replacement, such as spindles, shuttles, healds, reeds, bobbins, and pricking sticks. There was a shortage of these items during the war and their makeshift manufacture was taken up. The number of stores manufacturers has always been considerable. (3) Confederates of foreign manufacturers. There are few in this industry. All confederates began business after blanket import substitution started in 1957.

In the years following World War II, a large number of textile machines and accessories were being made by the first two types of firms; but they were making what were essentially prewar British models, and the orders they filled were mainly small replacement orders. New mills and mills taking up major reequipment programs still placed their large orders abroad. They did so, basically, because they trusted foreign brand names more, but the assumption behind this preference, that they would get a more standardized, more reliable machine than at home, was, perhaps, not without substance.

The situation changed after 1956. The sudden rise in imports wiped out the sterling reserves built up during the war and led the government to impose stringent quantitative restrictions on imports. The principle behind these restrictions was that if an item was being produced in India it could not be imported unless its Indian manufacturer could not supply it.

The import restrictions gave Indian manufacturers control of the entire Indian market if they could supply it with goods. Supplying it did not require much manufacturing during the early stages because liberal imports of components were initially allowed to be phased down in later years. There was, however, a boom in the textile industry, and the market for textile machinery was growing. To exploit it, a manufacturer had to be able to increase supplies rapidly. It also helped if the manufacturer could cater to the buyer's preference for a foreign brand name. The result was an enormous increase in the number of technology-import agreements (Textile Machinery Manufacturers' Association 1961).

It should be noted that the machinery manufacturers imported technology not because they had none, as was the case in a number of other industries, but because they could not otherwise have raised production fast enough or supplied as good machinery. There was considerable repetitive importing of technology. Not only was technology imported to produce machinery that was already being produced within the country, but manufacturers also imported technology for goods they were already manufacturing. In each case, the manufacturers imported technology not

to acquire a foreign name but to improve their own technology. Thus, the late 1950s saw a radical updating of textile technology and in 1965 the gap between Indian and foreign technology was narrower than ever before or after.

Three-quarters of the early technology import agreements were with firms in West Germany and Japan (Textile Machinery Manufacturers' Association 1961). Generally speaking, finishing processes, involved in product differentiation for the market, are operated on a smaller scale than the preparatory stages, i.e., spinning and weaving. Hence, a larger number of firms produce finishing machinery.

If what is known about technology imports into India applies to the textile machinery industry, it was not foreign machinery producers who sought to sell technology but Indian manufacturers who went looking for technology abroad. If so, the question arises: Why did they go to West Germany and Japan? Why did they not go, for instance, to Britain, which had, until then, been the prime source of textile machinery for India? It is impossible to answer this question with any accuracy 20 years after the event, but the answer probably is that technology from Britain was not readily available. The British textile machinery industry was more concentrated than on the continent and in Japan and it had its contacts with the Indian textile industry through import agencies in Bombay and Calcutta. Anticipating more restrictive import policies, Indian textile mills placed large orders for machinery with them in the late 1950s. Hence, it is likely that British firms failed to anticipate the tremendous advantage accorded to firms based in India by the new import policy and, therefore, to cash in on the Indian demand for technology.

The role of market structure on the supply of technology is worth stressing. Switzerland, for example, has a small number of large equipment manufacturers that, in the absence of an extensive domestic market, export a high proportion of their output. Technological superiority is an important selling point for them in the world market. These firms are, basically, exporters and will sell technology only when such sales would not conflict with their exports, i.e., when the technology sold is of an earlier generation or when the technology is accompanied by investment and, therefore, adds to the sales of the group.

In West Germany, on the other hand, there are a large number of firms, many of which are small, with a largely domestic or at most European market. For them, there is no conflict between their own sales and the sale of technology, particularly to a distant country that is unlikely to export machinery to Europe. Even then, of the West German firms that exhibit novel machines in the International Textile Machinery Exhibition, it is remarkable to note that only 5, of a total of about 20, have sold technology to India.

It may be argued that this is because there is little demand for advanced technology in India. This is true to some extent but Indian manufacturers have, generally, been quite aware of major innovations abroad and quick to take licences. The reason is that, because the textile industry is not a priority industry, equipment imports continue to be restricted on the basis of domestic capacity. A machinery manufacturer can secure the Indian market against imports, for a machine, at least for a time, by simply signing a technology import agreement. If the market develops, the return on the cost of the technology is high; if it does not, all that the technology importer loses is the initial payment. Technology imports are used to restrict potential competition from product imports just as industrial licences are used to restrict potential competition within the country.

Under the circumstances, technology import agreements have a speculative use: if the domestic market does not grow or the prospective technology importer does not have the capacity to exploit it, there is no need to import the technology. Often the prospective technology importer takes a licence from the technology supplier and then waits until a market develops for the product.

Between 1955 and 1965 the risk of going into production was less because the textile industry was expanding and, at least during the initial stages, manufacturers received such liberal import licences that they had to manufacture (or procure within the country) very little: the business was similar to assembling imported components and not much different from direct importing. A number of manufacturers held import agencies for some products and licences to produce others, and converted one into the other if the market seemed likely to expand steadily.

During the 1960s, however, as India's foreign exchange resources continued to fall short of industry's requirements, import licences were cut, more and more components had to be produced within the country, production and procurement became increasingly difficult, and equipment prices were progressively raised to maintain profit margins. This cost and price escalation continued until 1965. In that year, the cotton crop was poor, cotton prices rose sharply, a drought reduced rural demand for textiles, and the textile industry went into a slump. Despite

liberal credits given by the Industrial Development Bank of India for machinery purchases, the sales of textile equipment fell drastically. The firms that withstood the depression best were those that had specialized in high-wear items such as bearings, top arms, spindle inserts, and fluted rollers.

Conclusions

The promotion of small-scale production has been and continues to be an important element of Indian ideology and government policy. The means adopted to promote it in the textile industry consisted of discrimination in taxation and licencing against large mills and subsidies to small industry through the Khadi and Village Industries Commission and through cooperatives. On the whole, these policies have had little success in changing the technology mix, but they have had a strong influence, quite unrelated to policy objectives, on firm size and composition. They have prevented the growth of composite mills and have led to the installation of most of the new looms in extremely small enterprises.

Furthermore, they have had a number of unintended and, indeed, little-noticed effects. Under pressures created by them, the mill industry has improved its capital utilization and the quality of its product, and endeavoured to meet the competition presented by powerlooms by means of product differentiation. It has met the competition of new enterprises with new and better equipment by means of small improvements in technology and product, which have cumulatively added up to a substantial change. At the same time, however, it has produced less fine yarn than cotton supplies permitted, and, thereby, reduced national cloth output below its potential.

The developments within the textile industry have dictated the shape of the textile machinery industry. The small, new spinning mills and the even smaller weaving sheds have created a demand for cheap, simple, and sturdy spinning and weaving equipment. The improvements in the mills have required ancillary equipment such as high-draft systems, carding engines, and finishing machines and the increase in frame speeds has raised the demand for high-wear goods such as bearings. Hence, the textile machinery industry has based its foundation on ancillary equipment and items that wear. Although well aware of innovations being made abroad in the chief processes, the industry has, after having had problems with automatic looms in the 1960s, tended to specialize in old and tested equipment, waiting to bring in new technology until the domestic market clearly calls for it.

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Comments: Jamal Ahad Khan

So far, discussion has centred on the import of technology and its subsequent absorption, assimilation, and diffusion within related industries. In some of the papers the question of government regulations and market came up as a side issue. However, this paper deals primarily with govern-

ment regulations and their effect on the technology of the country directly or through market forces. This topic is of considerable importance because government regulations and market forces play a dominant role in the technology of any country.

The paper deals with the following government regulations: (1) support of the nonmill sector against the mill sector through the imposition of excise duty on the mill sector, subsidy of the nonmill sector, and provision of a market to the khadi and village industries; (2) support of the small-scale powerloom sector through an industrial licencing mechanism to encourage cooperative spinning mills; and (3) a ban on the import of machinery that could be manufactured locally.

From figures within the paper it is evident that: (1) the number of spindles installed increased with time; (2) spindle capacity utilization showed some fluctuations but an improvement, nevertheless, over the year 1950; (3) cotton consumption increased within the mill sector; (4) the increased use of cotton was mainly for finer counts of yarn; (5) labour utilization within the spinning sector rose over the year 1960; (6) yarn consumption (by weight) decreased within the mill sector but increased within the small-scale sector; (7) loom capacity utilization within the mill sector increased; (8) the amount of processed cloth increased within the mill sector; and (9) the number of technology import agreements in textile machinery mushroomed between 1961 and 1975.

The conclusion drawn is that the mill industry has improved its capital utilization; however, Table 2 shows that capacity utilization dropped from 74.9% in 1970 to 70.8% in 1975 and 67.5% in 1976. How much of the increase to 79.7% in 1978 was a result of an increase in the local textile market due to (1) reduction of imports; (2) reduction in price and, therefore, increase in total market; (3) growth in population; and (4) increase in per capita income compared with (1) improvement in the quality of cloth produced by the mill sector and consequent product differentiation; (2) restriction on expansion of mill weaving capacity; and (3) increase in exports? Without these answers the observation appears quite biased.

The paper states that the powerlooms employed in the small-scale sector "are plain looms, but they are no less efficient than plain looms in mills; if anything, they are newer on the average (although mills have not been allowed to increase their loomage since 1956 and have largely been operating with prewar looms, most of the powerlooms of the small-scale sector were acquired in the 1950s and 1960s)." If this is true and other conditions remain the same, the powerlooms should have been able to compete with the mill sector even in the manufacture of fine cloth. In fact, the study states that the "powerlooms have increasingly ventured into the production of fine cloth." Under the circumstances, the reasons why the mill weaving sector, with higher overheads and excise duty, has not been driven out of business have not been detailed.

The aspect of transfer of technology has been clearly identified through government sanctions against imported products that could be produced locally by increasing the import of technology through licencing. The paper, however, would have been much improved if it had also covered the role of the government regarding import vis-a-vis selection of source, contractual agreements, royalty payments, market restrictions, and restrictions on diffusion of know-how.

The Philippine ADIT Project: A Summary Paper

Luke Kho[1] and Lope Cuaresma[2]

Initial efforts in this study were spent trying to operationalize the key concepts developed in the Science Policy Research Unit International Development Research Centre workshop. Researchers attempted to relate "technology" and "techniques" and sought answers to such questions as: What is involved in each of the processes of absorption, assimilation, and diffusion? Where do they begin and end? How do we compare levels of absorption, assimilation, and technical capability between two companies? How do we actually measure them? What information must be known?

It later became apparent that these and other questions could not be settled satisfactorily without sufficient empirical data. Consequently, it was decided to interview textile experts and millers in an effort to elicit ideas that might be useful. The questions asked were related to conceptualization of absorption, assimilation, and diffusion. Unfortunately, in the initial interviews, the researchers could only glean general information about the state of the industry; little helpful technology-related information was acquired.

In the process of gathering background information statistics about the textile industry, it was realized that the industry is concerned with problematic aspects that, in the opinion of the individuals, were not related to technology. Some of the problems, for example, involved where to get money for day-to-day operations; how to discipline workers to increase productivity, upgrade quality, and minimize wastage; logistics related to the supply of raw materials and spare parts; and how to expand the textile market. Some millers, when interviewed, agreed that technological issues are secondary to the above problems, while admitting that technological change can effect a general improvement in the industry's performance. Capital, which the industry generally lacks, is needed for inducing technological change. Moreover, even if technological progress is made, there is still the question of: Would the market be able to absorb the increase in production or the higher quality products, even at lower production costs, and, thus, lower prices?

The need to deviate, though not totally, from the original research objectives, which touched mostly on technological development, processes (absorption, assimilation, and diffusion and measuring the levels of each; workings of technology transfer), and the factors variables, was observed. It was realized that if the study were limited to technological aspects, for which there was insufficient information to work with, it might not have provided a useful base for analysis. To come up with a more meaningful study, therefore, aspects considered important by millers and textile industry experts were studied. Furthermore, the technology concepts and definitions set before the start of the absorption and diffusion of imported technology (ADIT) study were not used as originally intended.

Nevertheless, as technology was still of primary importance, an interview outline dealing mainly with technology topics was used in gathering information for the case studies. It was hoped that technology-related (and other) information could be obtained from individual companies and used to answer some technological questions. It was also hoped that the information collected would allow comparisons of one mill with another to be made.

Unfortunately, the interview outline was not followed rigorously. The interviewees were either reluctant to answer most of the questions or impatient with the interview; others appeared disinterested. Most of the questions, therefore, were not answered. The interviewees generally

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discussed topics (nontechnological) that they considered more significant. Such digressions were interesting and much was learned about the industry from them. The result, however, was that it was not possible to gather parallel or similar information for the case studies. In addition, the information collected was incomplete, thereby allowing little or no analysis of it to be made. Also, the researchers found it difficult to conduct follow-up interviews, and much of the background information was considered confidential, nonexistent, or "sorry we could not find it."

Interviews were conducted with knowledgeable officials of government agencies (e.g., Philippine Textile Research Institute) and industrial organizations (e.g., Textile Mills' Association of the Philippines). The topics discussed in the interviews were of a general nature.

The researchers were also concerned about the sampling scheme used. Originally, firms were chosen at random, using statistical procedures. However, all of the firms, except one, proved so uncooperative that replacements had to be found. It turned out that the actual sample firms were those that cooperated with the study to a certain extent, a fact that could have a biased effect on the results of the interview.

Furthermore, although the study deals with the entire textile industry, only a list of integrated mills was used as the basis for sampling for the case studies. The decision to have this type of mill serve as the framework was reached after taking into consideration the following factors: (1) the firms' contributions to the Philippine economy (most of them belong to the top 1000 corporations in the Philippines); (2) the availability of data for the case studies; and (3) demonstration by these firms of the three basic processes (spinning, weaving, and finishing) in textile manufacturing.

Thus, the researchers encountered difficulties and were actually limited in their analysis. It is believed, however, that the data and information gathered, the analysis of it, and the results of the study still provide useful information about the textile industry in the Philippines and its problems and prospects.

Major Findings and Policy Implications

Machinery and Equipment

Need for Modernization

The existence of obsolete and inadequate equipment and machinery (most of which is of late 1960s vintage) contributes to the noncompetitive quality and price of local textile products. As a result, fabrics with uneven yarns, weaving faults, and poorly executed prints saturate the market at low prices only to be dislodged from the market by the intermittent appearance of cheaply priced, imported, mostly smuggled textiles. Only with newly installed mills that utilize modern machinery and more advanced technology can the textile industry produce highly competitive and exportable goods.

To modernize the equipment would require huge amounts of capital. The governments of some countries, such as Taiwan and Korea, have encouraged their textile industries to modernize by making available short- and long-term loans at low interest rates. In the Philippines, on the other hand, the textile industry is left to fend for itself, needing an estimated U.S.$100 million to modernize. Under existing conditions, however, the industry is not in a position to undertake a program of expansion and modernization, constrained as it is with a severe financial problem.

In this regard, the government could follow the Taiwanese and Korean example of modernization, i.e., encourage replacement or modification of obsolete techniques and processes of production through financial assistance (e.g., loans at lower interest rates), particularly to mills that export their products.

Preventive maintenance of machinery and equipment is another dimension to consider in relation to the modernization and updating of "embodied" technology. Researchers have found that a substantial quantity of equipment remains idle due to a lack of spare parts or due to improper scheduling of their purchase. Moreover, poor quality locally made spare parts, as well as a lack of technology "follow-through," contributes to problems with equipment and machinery. Centralized planning (e.g., by textile mills associations) for the procurement of spare parts and technology upgrading might be an interesting alternative to study.

Selection of Technology Suppliers

Inasmuch as the decision-making process for the acquisition of equipment and machinery is a major component of technology transfer, the choice of alternatives must be broadened to include all possible sources to enable millers to acquire the most competitive technology from among those having the latest state of the art in the industry. It was found that most decisions to purchase equipment from a certain supplier followed the bandwagon effect.

Government, as well as any international information clearing house, can remedy de-

ficiencies in information about other possible suppliers by undertaking on its own, or with the cooperation of prospective buyers of technology, economic and technical studies on different suppliers of textile equipment and machinery. International trade shows could be more widely publicized and prospective textile businessmen should be encouraged to attend. Thus, government financing institutions such as the Development Bank of the Philippines and the Central Bank, as well as policymaking bodies such as the Board of Investments, should take a more active interest in international sources of technology transfer.

Labour

Being a labour-intensive industry, the textile industry is persistently plagued by labour discontent and other labour problems. In general, Philippine labour productivity in the textile business has been very low compared with Japan and the United States.

Productivity will improve if modern machinery is installed. In addition, better training facilities for skilled workers are needed. Labour productivity will also improve if workers are not pampered by decisions on labour cases tending to favour the labour sector. Then, abusive and erring workers could be disciplined in a fair manner.

Labour turnover in the industry is very fast, with some of the workers transferring to other textile factories, some to other more promising industries, and many of the skilled labourers going to the Middle East. An estimated 5000 skilled labourers need to be replaced every year for the entire industry. These replacements also require training. The aspect of continually training labour for the textile industry is a matter that requires strengthening by the government and the private sector.

Noncompetitiveness of Philippine Textile Exports

Exportation in the textile industry can be classified into fibres and yarns, grey goods, finished fabrics, garments, and ready-to-wear articles. The export of fabrics and garments from the Philippines should be given high priority, due to their labour-intensive and high value-added nature, by upgrading their quality, thus making them competitive in the international market.

The local textile industry was started as an import-substitute industry. The machinery acquired then, and which is currently in operation, was designed to produce fabrics of 36 in. (0.91 m) width. At present, foreign markets prefer fabrics of 45–60 in. (1.14–1.52 m) width, thus making the local products unacceptable. Moreover, the local equipment and textile processing techniques are outdated, in addition to the problem of high turnover and low productivity of labour.

Thus, in addition to encouraging equipment modernization and continuous training of textile workers, the government can assist in quality upgrading by monitoring quality through on-the-spot checks and laboratory testing of textile and garment products and penalizing erring manufacturers. Although the government has recently established rules/guidelines on labeling of textile products, the system of checking and testing products has yet to be set up.

Entry of Imported Textiles

Local garment markets complain that the quality of locally produced textiles is still below that of products produced in other countries. In view of this, garment makers resort to importation of higher quality textiles.

Furthermore, because the Philippine market is volatile in its preference for changing fashions and colours, foreign products seem to gain market acceptance in the Philippines, thus contributing to rampant illegal entry of foreign textile products. Illegal entry is gained in two ways: outright smuggling and "technical smuggling," which invokes the provisions of Republic Act 3137, the "Embroidery Law," that allows the entry of embroidery materials, misdeclared and undervalued.

Due to the entry of imported textiles, therefore, the market for the local industry has been reduced considerably. Evidently, this problem calls for a renewed drive against illegal entry and sale of foreign-made textiles, although in the past years, smuggling has not been as rampant and problematic as in the 1960s.

Raw Materials

The problem of irregular supply of materials for the synthetic textile industry has been partially alleviated by the establishment of synthetic-fibre manufacturers. The local production of raw cotton and rayon is not enough to supply the needs of the textile manufacturers, thus making the industry dependent upon foreign sources and, in turn, leaving it vulnerable to price inflation, peso to dollar exchange rate fluctuations and foreign logistics supply problems, and, most of all, the monitoring of quality.

Millers complain that the quality of cotton fibres shipped to them is of lower grade than what

they specifically ordered. In addition, the importation of cotton entails high cost. Mills pay 10% duty plus 10% sales tax. Because the tax is computed on a 25% markup of the landed cost of raw materials, local millers are at a disadvantage compared with millers in Hong Kong, Korea, and Taiwan who do not pay taxes on cotton imports.

If imported raw materials are exported as finished goods, the local millers are refunded the taxes they have paid. However, according to the head of the Textile Mills Association of the Philippines: "You can get your refund from six months to one year from the time you paid the duties and taxes. All the while, the money tied up is not earning any interest; if it is borrowed from the banks, the interest naturally accrues."

The high price of imported cotton, polyester, nylon, rayon, and acrylic materials is also reportedly due to the small-sized orders being placed by local millers. Locally produced nylon and polyester, which can meet only 50% of the local demand, generally cost more than imported nylon and polyester. The importers of nylon and polyester yarns, therefore, have some difficulties because of the protection that the government accords local producers.

Domestic Fluctuations due to Changes in Fashion

Due to a highly volatile market preference for fashionable designs and colours, the textile industry, being a supplier to the garment makers, faces the problem of demand and supply uncertainties brought about by market forces over which it has little or no control. Thus, the textile manufacturers cannot expect a smooth movement of inventory and, consequently, a predictable cash flow. Moreover, because garment manufacturers and yarn suppliers are distinct organizations, the building up of inventories by garment makers and distributors cannot be controlled or checked by the millers, thus making the lean period following the buildup unpredictable.

Financial/Cash-Flow Problems

High interest rates plague the textile industry. Local rates range from 14–16%. In comparison, rates in Hong Kong, Korea, and Taiwan do not exceed 8%.

Most of the textile mills are heavily indebted to certain government and private financial institutions. Still, there are cash-flow difficulties, despite the fact that the above-mentioned debts can be attributed to the increased peso cost of imported raw materials, supplies, and spare parts and also the amortization on existing foreign obligations, the increase in minimum wages for skilled labour, unpredictable fluctuations in inventory and sales, and the high cost of capital. It should be noted that the tight cash-flow situation is so serious and unpredictable that some textile company officials find it convenient to buy into commercial banks and sit on the board as directors.

Capacity Utilization

The relatively low utilization rate of installed capacity is partly due to: (1) difficulty in securing imported spare parts causes many machines to remain idle; some mills have failed to reach a proper balance between the cost of lost production when machinery lies idle due to a lack of spare parts and the capital cost of stocking spare parts; (2) delays in the delivery of imported raw materials forces some millers to stop operations; (3) demand for many fabric styles and designs causes production lags in various product lines; (4) imbalance among installed capacities: weaving and knitting capacities far exceed spinning capacity so that millers still import part of their yarn requirements; and (5) competition from imported fabrics results in a reduced market for local textiles.

Integration of Mills

Some industry experts express regrets on the past movement toward integration. Most integrated mills have been experiencing problems that arose as a result of undertaking spinning, knitting and/or weaving, and finishing operations all at the same time.

Older mills do not have the ideal functional layout patterns of the newly installed mills, the reason being that, as the old mills integrated, additional equipment was squeezed into existing buildings or additional structures were erected with a view toward minimizing capital costs at the expense of operating efficiency.

Quality has also suffered due to integration because tolerance levels between spinning, knitting and/or weaving, and finishing departments in an integrated mill are much lower than those in companies specializing in one or two operations.

Lastly, management of a large integrated mill has caused problems due to the diversity of the operation. Although the integration of mills would be very difficult or even impossible to reverse, the experiences of integrated mills should be noted by nonintegrated mills that plan to diversify into other textile operations.

Poor Management Practices

The poor quality of locally produced textiles is also due, in part, to: (1) buying cheap raw materials that become more expensive in the long run due to difficulties in processing; (2) lack of capital, which means that equipment replacement cannot be undertaken without borrowing more capital; (3) insufficient programs dealing with spare parts acquisition, raw material purchases, maintenance, equipment replacement, and personnel training; (4) failure to decide what products to manufacture and how to market them; (5) failure to realize that vertical integration introduces more management difficulties; and (6) keeping information from staff (e.g., on costs), thus preventing staff from supporting or advising management.

It is obvious from the above that the problem of absorption and diffusion of imported technology in the Philippine textile industry is a combination and interrelation of multidimensional factors. One can trace the entire problem, however, to stiff competition in domestic and international markets driving profitability, as well as cash flow, to the bottom line. As a result, the Philippine textile industry, with the exception of a few companies, is plagued by problems of low profitability, low productive efficiency, and poor quality output. These problems have definitely contributed to the noncompetitiveness of Philippine textile products in the international market, and, thus, discouraged new investors, as well as talented management experts, from entering into the industry. On the other hand, these conditions are ideal for technological change, accompanied by a management breakthrough in corporate planning and organization, as well as framing up of appropriate fiscal policies hand in hand with the government. One possibility is the removal of tariff protection from imported textiles. Government support is needed in the area of lowering tariffs on the importation of raw materials and a ban limitation on imported textiles or garments. The removal of incentives is aimed at improving the competitiveness of the industry. The government hopes that inefficient plants either improve or phase out of the market. Furthermore, with the lifting of the tariff protection, the government hopes that textile prices will fall because textiles are a basic consumer need and an essential raw material for the growing local garment industry.

It should be noted that the above policies, if implemented, mark a shift from past government policy of support and protection stimuli and competition. The preference given to the development of the local garment industry, which is labour intensive and export oriented, seems to indicate the growing dissatisfaction of government funding agencies with the results of its support in implementing "technical change" for the textile industry in the form of equipment purchase. It is hoped that the shift of attention to the garment industry may result in simultaneous stimulation of quality output for the textile industry.

Finally, closer cooperation between the government and the industrial sector is in order. No amount of government willingness to assist can improve the industry if the private entrepreneurs do not work with the government. Private millers should contribute financially or otherwise in efforts to improve the industry's performance and capability. They should cooperate in government surveys and other studies (such as the ADIT project) that are useful to policymakers and industry planners. Many private businessmen are reluctant to provide information required by government studies despite penalties for noncooperation. Moreover, private companies should implement their own policies and measures to upgrade their individual performances in areas where the government cannot help, e.g., poor management practices and work discipline.

Conclusion

Although this study does not lend itself to forming general conclusions and propositions regarding the textile industry in the Philippines, it has revealed the turbulent and dynamic nature of the interactions between industry variables and the external environment.

Comments: W.D. Lakshman

These comments refer to the comprehensive report prepared by the research team from the Philippines.

One of the objectives of international network research of the ADIT type is to develop some comparative perspectives on the research topic. The Philippines study, however, is an illustration of the difficulties involved in achieving this objective. The main difficulties encountered by the research team are concerned with obtaining relevant data. Although the study started with the objective of examining technological development, i.e., absorption, diffusion, and assimilation of technology, within the textile industry of

the Philippines, it was necessary, because of data limitations and the uncooperative attitudes of the firms interviewed, to deviate from the technology concepts and definitions agreed upon by the research teams in the network.

Little harm is done, however, by not adopting a particular set of definitions — after all, any set of definitions in this area would be arbitrary — but some definitions and a clear conceptual framework are required to undertake a useful study. In this regard, the research team does not seem to have evolved an alternative set of definitions In fact, in their attempt to study all the aspects of the textile industry considered important by millers and industry experts, they have produced a useful source book, subject to limitations, of course, about the textile industry in the Philippines but whose place in the present research network is difficult to understand.

It is pointed out that, in the mind of those in the industry, the problems facing the textile sector in the Philippines are not technologically related. This position, however, does not seem to have been accepted by the authors of the study. The position that the problems of the industry are not technological is interesting because technology seems to have been viewed in a rather narrow sense. Some of the issues the industry seems to consider crucial, e.g., how to upgrade quality and minimize wastage, cannot be dismissed as non-technological problems. Undertaking a study of the textile industry that will be considered useful by industrialists has one advantage, it makes implementation of its recommendations easy at the firm level. It could be said that if this was done while remaining broadly within some agreed upon framework, the study would have been more useful within the present comparative network research.

The study begins with a chapter dealing with some overall magnitudes of the textile industry in the Philippines. The data used are obtained mainly from two sources, referred to by the authors as the BOI and MI-CB preliminary reports. The chapter examines the historical growth and present position of the industry. There is also an examination of the responses of textile engineering graduates within the country to a questionnaire administered by the researchers, although the exact relevance and purpose of the exercise is not clear.

The rest of the report is based on nine case studies: four textile-manufacturing companies and five synthetic-fibre manufacturers. The section on methodology in the abstract presented for discussion explains the basis for the selection of these firms for study and the possible biases that could have entered into study findings as a result of not being able to adopt a proper sampling method for choosing firms for intensive study. It would have been useful if the relative position of the firms studied, within the country's textile sector, was statistically indicated. It should be noted that in terms of the number of textile firms within the Philippines, the chosen sample of nine constitutes about 5% of the total. Because the chosen firms are relatively large, in terms of size indicators such as production or employment, their share in the total industry would be higher than 5%.

The report goes on to examine the history, present performance, and problems of each of the nine firms. These descriptive accounts are often devoid of any statistical analysis, except for the data one normally finds in financial statements. I am sure a lot of effort would have gone into collecting this information, particularly when one considers the tremendous hostility the researchers seem to have faced during their interviews. If the data, so laboriously collected, were analyzed with the proper perspective to achieve a set of predetermined research objectives, the usefulness of the study could have been greatly enhanced. The first case study on Ramie Textiles Inc., based, apparently, on the findings of another research thesis, in addition to the present research team's survey, is very interesting. In the descriptive style adopted throughout, the authors discuss various technological challenges faced by this firm from time to time and how it found, essentially through its own efforts, suitable solutions to these problems.

The authors do not attempt to produce a synthesis of the individual case studies but, with qualifications about the validity of generalizing on the basis of the limited number of cases studied, try to present their findings in a summary and conclusions chapter. The focus is on the general problems of the textile sector in the Philippines. Some effort to focus more specifically and directly on problems of technological change and development in the textile sector would go a long way toward making the content of the study more agreeable with its title.

Absorption and Diffusion of Imported Technology: A Case Study in the Republic of Korea

Woo Hee Park[1]

Methodology

Scope and Definition

The objective of this inquiry was to learn as much as possible about the absorption and diffusion of the industrial technologies that have been imported into the Republic of Korea from more advanced economies. Attempts were made to answer several questions: What techniques were available, which one was chosen, and why? Through what agency was the technology transferred? Which individuals, of which nationalities, and with which skills were involved? With what organization were these individuals affiliated? How rapidly and efficiently was the technology absorbed? What changes were made in the process and why? What improvements were subsequently made: by whom and with what consequences?

Common to each of the four case studies to be discussed was the set of questions to be answered and the definition of the terms "technology," "absorption," and "diffusion." Technology was taken to mean the entire body of knowledge necessary to fulfill a specific task, usually the production of a commodity. This would include the knowledge required to conceive the manufacturing technique; design and construct the plant and equipment incorporating the technique; bring the plant into operation; maintain efficient production; train all personnel involved; and secure improvements in existing operations and advance to superior techniques. Thus, the concept of technology includes knowledge of the manufacturing process or technique as well as knowledge of all the additional activities of applying, altering, and improving the technique.

Absorption refers to the process by which the imported technology is learned by one or more residents, usually working together, in the developing country, such that they can carry out all of the activities covered by the technology independent of the transferring agent from the developed country.

Diffusion refers to the further spread of technology, from its initial application, throughout the developing country. In principle, diffusion would be complete when everyone, producer or potential producer, has acquired the technology. In practice, however, diffusion will only be partial because, at best, knowledge is costly and time consuming to acquire and, at worst, it may be impossible to acquire due to secrecy or legal prohibition.

Measuring Absorption and Diffusion

Measures of absorption can be based upon labour's contribution, capital's contribution, and the contribution of all inputs taken together. "Labour absorption" is the proportion of individuals needed to carry out each phase of the process of absorption of technology, represented by nationals of the developing country, in this case the Republic of Korea. If Korean citizens are absent during a phase, the measure of absorption is zero; if they are omnipresent, the measure is unity. These two values, zero and unity, set the bounds, and the actual values will lie within their span.

"Capital absorption" covers only one phase in the process, the operating phase. If one imagines that the equipment incorporating the technique attains a particular rate of output when being operated at its full potential, this figure can be compared with the actual rate of output. To the extent that the actual rate of output approaches, or even surpasses, the design rate, the technique

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can be said to have been absorbed. Again, there will be a lower bound, of zero, to the absorption of capital; but there will, in principle, be no upper bound.

Both of these measures are appropriate only if all other complementary inputs, e.g., labour in the case of the measure of capital absorption, are present in sufficient amounts. If, however, there is not enough skilled labour, or raw material, to operate the equipment fully, then the actual rate of output as a fraction of design output is meaningless as a measure of capacity absorption. The third measure of absorption, unit or average cost as a fraction of some standard cost, does not suffer from this limitation because it allows for the contribution of all inputs together. Its limitation is that "standard cost" is not unambiguous: the "standard" could be the cost per unit at the full capacity rate of output, either as estimated when the equipment was designed or as encountered when the equipment was first operated at full capacity, or it could be the cost per unit incurred when the equipment began commercial operation, which accords well with the theory of cost reduction via learning.

With regard to measuring diffusion, the sequential pattern, through time, of adoptions by firms in the industry is not appropriate for the case studies discussed here except, possibly, that of the textile industry. The other industries are all monopolized, so the first adoption is the only one. To find measures of diffusion one must look to the suppliers of inputs for the firm absorbing the technology or to the customers. The most significant suppliers of inputs for developing countries are the capital-goods manufacturers: the higher (in value terms) the fraction of the plant and equipment supplied by local capital-goods manufacturers, the further technology has diffused. The same sort of measure can also be applied to suppliers of other inputs, e.g., materials or energy. If the basis for the measure of diffusion is the total cost of all inputs, then a more complete measure of diffusion to suppliers would be the fraction of the total cost of inputs supplied by domestic firms.

Similar quantitative measures do not exist for diffusion to customers; only general observations on the flow of technical knowledge to users of the product, e.g., universities, technical schools, and government.

Summary of Case Studies

Petrochemical Industry

Role of the Korean Government

The Korean government has affected the outcome initially by specifying output targets in successive Five-Year Economic Development Plans, which determine the reallocation of scarce resources. The scale of individual projects has been influenced by the government's penchant for large plants; swayed by the argument that substantial economies of scale exist in modern petrochemical plants, the Korean government has usually granted monopolies in the production of the targeted output when production is being undertaken in Korea for the first time, or in the increase in targeted output when expansion of existing production is being undertaken. Therefore, the entire initial capacity is installed by one firm, and any increase in capacity between one plan and the next is also installed by one, occasionally the same, firm. In this way, the government has had its first effect on the rates of absorption and diffusion: absorption generally takes place at a slower pace in the larger plants than in smaller plants, and diffusion occurs at a slower pace in monopolistic industries than in competitive industries.

The Korean government's next concern was the degree of foreign ownership of petrochemical plants — none, part, or complete. Torn between conflicting desires of economizing on scarce foreign capital and retaining possession of productive assets for Korean citizens, the government chose fifty-fifty joint ventures, the only exceptions being the wholly domestically owned Hankook Caprolactam Corporation's plant at Ulsan and Dow's wholly owned chlorine-alkali plant at Yeocheon. This precludes any choice of technique because the foreign partners always employ, in Korea, the same technology that they have employed successfully at home.

Picking a foreign participant, therefore, inevitably means picking a technique, with its subsequent effect on the rates of absorption and diffusion. Picking foreign participants in the petrochemical industry has meant picking capital-intensive processes of great technical sophistication, whose absorption and diffusion would be expected to be slow. Rather than denying the country the benefits of employing modern capital-intensive techniques, however, the Korean government has tried to compensate for the greater difficulties with respect to absorption by imposing conditions upon the foreign participants. For example, in the case of Korea Pacific Chemical Corporation (KPCC) the major conditions were fivefold: (1) the foreign partner, Dow Chemical, would reveal all of its designs and know-how to its Korean employees; (2) Korean engineers would be trained by Dow in the application of all the aspects of Dow's current technology — basic process design, detailed

equipment design and procurement, construction, testing, start-up, operation, and maintenance — and in the techniques employed in securing improvements to petrochemical technology; (3) Korean engineers would participate in each of these activities as quickly as possible and in sufficient numbers to replace Dow's expatriate engineers; (4) with some qualifications, Dow would automatically inform KPCC of improvements in the imported technology made by Dow or any of its licencees; and (5) KPCC could object, to the Korean government, if it ("it" being the president and executive vice-president of the firm, both Korean citizens) felt that Dow was not proceeding rapidly enough with the technology transfer process.

Conditions such as these are common to joint ventures in the Korean petrochemical industry and have even been imposed upon joint petrochemical ventures in other developing countries; but their enactment from country to country has been quite varied. In Korea, for example, they have been implemented both speedily and effectively. Another role the Korean government has played in the creation of the petrochemical industry is that of leader. The government has never withdrawn its interest in the industry, nor have ministers, planners, or other civil servants slackened in their enthusiasm and determination to secure maximum output and efficiency. In addition to government support, another factor urging the KPCC and other petrochemical firms on is the fear that the Korean government will accept nothing less than proficiency from them.

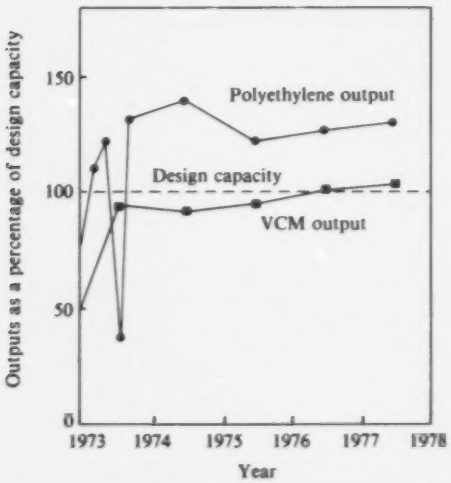

Fig. 1. Output of polyethylene and vinyl chloride monomer at the Ulsan plant as a percentage of design capacity, 1973–1977.

Evidence indicates that the degree of commitment of government to a country's economic development is closely related to the country's overall performance; the Korean government's attitudes and behaviour and the petrochemical industry's achievements conform to this pattern.

Finally, the Korean government has tried to make available the resources necessary for Korean petrochemical firms to operate efficiently. Inputs, particularly the raw materials from petroleum, have been continuously provided in sufficient quantity to maintain production rates at full capacity. More importantly for the absorption of technology, however, is the fact that engineers have been educated at universities and given their initial experience in public firms (particularly the fertilizer producer, Korea General Chemical Company) and operators have been trained at technical schools in sufficient numbers to completely staff petrochemical firms with Koreans. Education in technical subjects is given high priority by a government dedicated to the industrialization of its economy.

Absorption of Imported Technology

Throughout the establishment of the Korean petrochemical industry, it was essentially the government's decisions that determined what type of technology would be imported and what means would be available to absorb it. The result was rapid and successful absorption of petrochemical technology.

Figure 1 illustrates the yearly rates of polyethylene and vinyl chloride monomer (VCM) production at KPCC's Ulsan plant through the years from its process design, commencing in 1970, to its start-up in January 1973, until the end of 1977. The graph of polyethylene production shows that full design capacity output was surpassed after 6 months and, except for a brief period in 1973, has never since fallen below that level. The graph of VCM production shows a quick start-up and steadily rising production, but failure to reach design capacity until 1976, 3 years after start-up. If the standard for full absorption of technology is the rapid attainment of high and sustained rates of output, KPCC can be said to have achieved it almost immediately; if, on the other hand, the standard is the attainment of rates of output equal to or exceeding the capacity for which the plant was designed, KPCC can be said to have achieved it after approximately 2 years, the average for the two products.

There is a distinction to be made between absorption by a firm and absorption by a nation. The latter is a more stringent concept, because a company can absorb a technology completely without using any engineers native to the country

in which it is operating. To the extent that KPCC absorbed the low density polyethylene (LDPE) and VCM operating technology with Dow Chemical's engineers, the absorption cannot be said to be complete from Korea's point of view. Only when the Ulsan plant was operating steadily, or at full capacity, with Korean engineers in full command would absorption be complete in national terms. Figure 2 illustrates this point.

In Fig. 2 the upper horizontal axis, relating to the experience of the plant at Ulsan, extends from 1970 1977. The lower horizontal axis extends over an equally long period, October 1978 October 1983, appropriate for the Yeocheon plant. Thus a point at the top of the graph (equal to 100%) indicates wholly foreign participation in the technology and a point coinciding with the horizontal axis (equal to 0%) indicates wholly Korean participation.

The two plots in Fig. 2 refer to the course of participation in the first of KPCC's petrochemical plants at Ulsan and the second at Yeocheon. As would be expected, the second plant, occurring about 6 years after the first and exploiting what had already been learned, utilizes Korean engineers to a greater extent. The dramatic shift downward occurred in the design and procurement stages of the technology; Korean engineers demonstrated that they had at least partially absorbed these difficult technical tasks. Nevertheless, if one is strict in one's definition of absorption, only 100% participation by Korean engineers in all stages would indicate complete absorption of the technology.

Used in conjunction, Figs. 1 and 2 indicate how quickly Korean engineers were capable of sustaining, on their own, either a high rate of output or full capacity operation.

Thus, when reasons are sought for the rapid rate of absorption of petrochemical technology in Korea the answers become largely subjective. The necessary human resources have been available, as a result of government's foresight in stressing engineering education and training; there have been carefully designed and rigorously implemented plans for the transfer of technological knowledge and experience from Dow Chemical's American engineers to KPCC's Korean engineers; and there has been a large

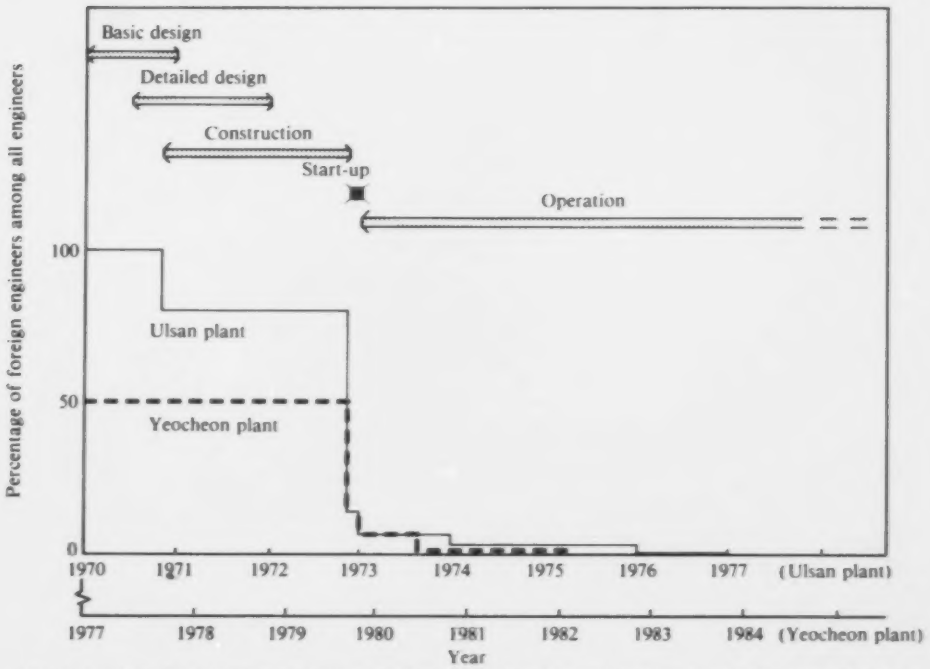

Fig. 2. Participation of foreign engineers at various stages in the absorption of imported technology at the Ulsan (1970–1977) and Yeocheon (1975–1982) plants.

market in Korea eagerly demanding all the petrochemicals that can be produced. Nevertheless, the Korean government's impetus and Dow Chemical's cooperation were not, even together, sufficient to explain the rapid absorption. In addition, therefore, it is suggested that the rapid absorption may also be due, in part, to the desire of Korean engineers to acquire modern technical knowledge.

Diffusion of Imported Technology

Diffusion of imported technology in the Korean petrochemical industry has been slow. Diffusion to other firms manufacturing the same products has seldom occurred, for the simple reason that there has not been, and will not be before the completion of a third petrochemical complex, much competition. Where competition has existed, as in the manufacture of caprolactam, engineers have moved in some numbers from the first firm in production to its two successors. Where competition has not been created, as in the case of KPCC's products LDPE and VCM, there has been almost no turnover of personnel at all.

At the same time, however, it is chiefly through the movement of engineers from one petrochemical firm to another, or chemical firms in general, that diffusion can take place in Korea. Engineering principles are freely communicated, but all the technological knowledge that is collected under the term "know-how," without which plants and equipment cannot be designed, constructed, and operated, is not. Know-how accompanies licencing agreements, but in their absence moves only as a result of engineers who change employment. If Korean engineers working in the petrochemical industry do not change employment, their know-how will not be deployed.

That know-how should be kept secret within a firm is not a Korean institution but one acquired, along with the technology, from the petrochemical industry of the developed world. When Korea imported petrochemical technology, it necessarily imported the manner of handling the technology; it would not have received the technology unless it had agreed to honour its privacy. Perhaps the Korean nation could get along without the secrecy surrounding the know-how, but it could not have got along without the know-how itself, and it had to accept the former to obtain the latter. In this manner, the international scheme of confidentiality has been imposed upon the Korean petrochemical industry, and has reduced the diffusion of the imported technology within it.

Diffusion outside the petrochemical industry has occurred to some extent, mainly through dissemination of knowledge related to equipment design and construction to capital-goods manufacturers. Although there has been a steady increase in the fraction of locally produced capital equipment incorporated in Korean petrochemical plants, it is difficult to state how much further localization of equipment can and should proceed.

Thus, the rate of absorption of imported technology in the petrochemical industry has been rapid, and substantial improvements have been made in that part of the technology relating to ancillary processes. The rapid absorption has stemmed from the Korean government's policies and actions, the foreign participants' planning and experience, and, above all, the attitudes of Korean engineers. The rate of diffusion of the imported technology, however, appears to have been much less rapid, as expected in a young industry, most of whose firms have been granted producing monopolies. The secrecy endemic to petrochemical and chemical industries helped to retard diffusion, whereas the government's program of equipment localization has helped to accelerate it. Finally, the Korean government, in its many roles, has exerted a strong influence on the choice of the technology that is to be imported and an equally strong influence on the speed with which the technology is absorbed.

Iron and Steel

Pohang Iron and Steel Co. Ltd. (POSCO) was the nation's first integrated iron and steel mill with a modern and large-scale continuous production system of iron and steel making and rolling. Most of the technology necessary for the construction and operation of the mill was imported. Because the capital requirements were met through the introduction of a credit line with Japan, a considerable part of the technology and facilities was imported from Japan. Under technical project contracts, the Japan Group (JG) advised and guided the construction and operation of POSCO. Little by little, POSCO has accumulated technology and is going to expand its fourth-stage facilities with its own accumulated technology.

Pohang Iron and Steel Co. Ltd. has seen remarkable progress in the absorption of technology related to planning and construction engineering, whereas core technology, such as the design and supply of facilities, is still primitive. The rapid absorption of field engineering technology can be largely attributed to the training of POSCO engineers in developed countries and the use of highly skilled and educated foremen.

Development of steel products has centred on plain carbon steel, used for general structural purposes, equipment, and in core technology. Thus, the development of the machinery industry is urged along with the steel industry. Because POSCO has only a 10-year history of technology accumulation, its expenditures on research and development are negligible.

Machinery

Role of the Korean Government

During the First and Second Five-Year Economic Development Plans (1962 1971), with capital accumulation and the scale of industries at a relatively low level, business enterprises in Korea could finance most of their equipment through foreign loans rather than public issues of stocks and debentures. Under these circumstances, the Korean government, being aware of the far-reaching impact of foreign investment on the national economy, established guidelines for foreign capital inducement.

(1) In order o ensure sound financial structure, entrepreneurs undertaking heavy and chemical projects were requested to secure their own capital for more than 30% of the total investment. Foreign capital was to be limited, in principle, to not more than 60% of the total investment. Foreign loans and investments were to be utilized, when required, for the acquisition of capital goods and advanced technology that were not available locally.

(2) Although priority was given to loans with favourable terms, direct foreign investments were also to be authorized. Such investments were to be encouraged, particularly when they would help secure dependable sources of raw materials, expand markets for products, or induce the input of advanced technology.

(3) In order to effectively support the development of the heavy and chemical industries, tax privileges under the Foreign Capital Inducement Act and other tax laws were prepared and presented by the government. Income and corporation taxes on foreign-invested enterprises were exempted or reduced in proportion to the percentage of stocks or shares that foreign investors held in the enterprise. Other taxes were also subject to reductions or exemptions.

(4) Industrial sites were selected and constructed under governmental initiative. In order to support construction of the selected industrial sites, the Industrial Site Development Promotion Law was enacted in 1973, and the Korean Water Resource Development Corporation, established in 1967, was reformed into the Industrial Site Corporation.

Because the less-advanced industrial structure and resulting heavy import of capital goods, as well as industrial raw materials, have not only caused serious balance of payment problems but also made the economy more dependent upon foreign savings, basic governmental policy focused on the enhancement of industrial independence through increased domestic production of industrial raw materials and capital goods. With a view toward enhancing self-sufficiency in industrial raw materials, the steel, petrochemical, and nonferrous metal industries have been selected for intensive development. On the other hand, in order to promote self-sufficiency through localization of capital goods, equipment, and parts, the government also selected the machinery and electronics industries as industries destined for emphasized support.

Absorption of Imported Technology

During the course of the case study, a conclusion was drawn that the absorption of imported technology is highly dependent upon the continuity of demand for the products produced by the technology. For example, during the early stages of diesel engine production in Korea, there was not enough demand in the market for the engines. Hence, personnel employed in the diesel engine project were transferred to other projects. The company could not afford to keep personnel working on the project when it was losing money due to a lack of market demand for the product. Thus, when the continuity of personnel engaged in the technical activities of production is broken, the continual accumulation of technical knowledge in the related area will also be seriously hampered.

Because the technology involved in the production of diesel engines is sophisticated, it is not to be expected that Korean engineers would accomplish major technical changes in a short period of time. However, during the 4 years of successful operation of the plant, there have been numerous cases of technological improvement, which were motivated through the movements of raw material savings and loss prevention. These movements were integrated as part of the Saemaeul Movement, which was a government-sponsored nationwide activity encouraging the whole nation to be more productive and constructive through maintaining new attitudes and spirits. The movements resulted in the production of ductile cast iron, the invention of new methods by which raw materials and expendable supplies could be saved, and the reduction of defective products. All of these technological improvements were conducive to lowering costs.

Diffusion of Technology

As in the petrochemical industry, diffusion of the imported technology to other competing firms took place through engineers who moved to other competing firms to obtain promotions and higher salaries. Furthermore, when they moved from one company to another, the movement involved not just one individual but a group – a group that worked together as a team in the previous company. This kind of manpower movement, which was prevalent between 1975 and 1978, was sometimes detrimental to the accumulation of technological capability within the firm that lost the precious technical manpower.

Diffusion of technology to input suppliers has been slowly taking place. Diffusion to suppliers in the machinery sector came, interestingly, from a need that is intrinsic to the sector. Because a machine is an assemblage of a large number of parts of components functioning together systematically to perform a specified function, the quality level of a machine will be determined by those parts with the lowest quality level.

A machine manufacturer should, therefore, recognize the need for cooperation and coordination among firms engaged in machinery manufacturing. Daewoo Heavy Industry Ltd. (DHI), fortunately, was aware of this need and established, in line with government directives, a program for the localization of materials, equipment, and parts by providing smaller parts manufacturers with technical know-how and, sometimes, financial support. The successful accomplishment of the program made significant contributions to cost reductions and foreign currency savings.

Basically, engineers at DHI have absorbed those portions of the imported technology relating to the start-up, operation, and maintenance of diesel engine manufacturing processes. However, basic design and research and development, particularly when the technology involved is highly sophisticated, are still far from having been absorbed or diffused. In order to determine the impact of the degree of sophistication of the technology on its absorption and diffusion an analysis of a simpler technology was made for comparative purposes. The analysis suggested that when a developing nation needs to learn, absorb, and diffuse imported technology, it should start with a simple technology because simpler technologies are absorbed and understood with much more ease than sophisticated technologies. However, when developing countries want their products to be competitive in international markets, the quality requirements of the products call for the importation of foreign techniques that are usually sophisticated. Thus, a developing nation faces a conflicting situation between a long-term optimization of technology development and a short-term optimization of international trade.

Textiles

The absorption and adaptation processes of nylon technology at Kolon Co. Ltd. seem to be very successful. The company achieved smooth absorption of technology in the areas of start-up, operation, maintenance, and design. The technology was fully and rapidly accumulated in both human and capital resources. Because engineering skills are somewhat different from the skills of the above fields, the company relied upon Chemtex Engineering many times during its expansion and new construction phases.

Intimate technical and capital cooperation with Chemtex and Toray Co. also played a crucial role in Kolon's development. Favourable economic factors such as the planning and implementation function of a strong government, increased and adequate demand for nylon products, price stability, etc. were also very important.

As well, the company has adopted a positive technology policy. In addition to regular on-the-job training, the company systemized general refinement and training for newly hired personnel. It also oversees all training, quality control activities, and research and development activities; has established an improvement proposal system and a patent section; and continues efforts to drive costs down. All of these policies have helped the technology absorption and diffusion processes.

Based on the experiences of Kolon Co. Ltd., several implications regarding technology absorption and development can be made: (1) Particularly during the early stages of technology absorption, it may be better for the importing firm to maintain as intimate a relationship as possible with cooperating firms. (2) As the accumulation of imported technology reaches a certain level, government, as well as related industries or firms, must be very careful to choose an appropriate time to switch from heavy technology dependence to direct research and development promotion. (3) In some cases, joint venture arrangements could help the smooth transfer of foreign technology. (4) The accumulation of minor technological changes at Kolon Co. Ltd. contributed significantly to upgrading its technology. Therefore, various devices that encourage minor in-plant technological improvement should be pursued. (5) Plant expansion and

diversification of products were also sources of technology improvement at Kolon Co. Ltd. Thus, expansion and diversification policies should also be encouraged. (6) As the accumulated technology of a firm matures to a certain internationally acceptable level, the government might consider encouraging the firm to establish a subsidiary engineering firm. This, of course, would not be suitable for every field of various industries, but the possibility should be taken into consideration because an engineering firm backed by a large-scale and technically advanced mother company can break new ground for technology diffusion abroad. (7) Long-term loans are frequently necessary for plant export or diffusion of know-how. Therefore, either government or industry should be ready to arrange such loans for exporting firms. (8) It is very important that the government take measures to protect industrial ownership and subsidize firms to help minimize the technical risks they must encounter as pioneering and leading firms. (9) Government and business would be wise to convene relevant social or industrial conventions to prevent pirating activities among competing firms.

Conclusions and Policy Suggestions

The primary hypothesis of this paper has been that exports and economic growth are facilitated by proper and rapid absorption and diffusion of imported and indigenous technology, i.e., absorption and diffusion of technology affect the level and direction of trade. Comparative advantage shifts from one country to another when the technology needed to produce new goods is acquired by countries with less factor costs. Importing nations may turn out to be exporters and exporting nations importers. Within a country, absorption and diffusion at the producer level tend to reduce imports and increase exports, whereas at the consumer level they have the opposite influences. Absorption and diffusion of demand and production may also proceed at an equal pace depending upon whether or not there is trade. With trade, absorption and diffusion among producers are constrained by domestic supply factors but are freed from domestic demand factors because exports are possible. Without trade, unfavourable conditions in supply and demand factors inhibit absorption and diffusion.

Furthermore, the problem of technological development should be considered simultaneously with the specific and interdependent aspects of importation, absorption and diffusion, and innovation. These aspects are closely intertwined in relation to technological development and it is not possible to separate them from each other. The speed and extent with which imported technology is absorbed and diffused should be considered together with the importation and innovation of new technology when necessary.

The above are all important policy concerns for which, as yet, there are no definite answers in Korea and, for that matter, in any other developing countries.

From this work, some important findings concerning various factors that influence the degree and speed of absorption and diffusion can be derived. The factors exist in the following forms: government policies and actions, foreign participant's planning and experience, and the attitudes and application of Korean engineers in the case of the petrochemical industry; training of engineers, highly skilled and educated foremen, stable demand, monopolistic market share, and expenditure on research and development in the case of the iron and steel industry; government role, secured market, degree of technological sophistication, and supply of parts in the case of the machinery industry; and intimate relationships with cooperating firms, research and development promotion, joint venture, improvement of minor technologies, plant expansion, product diversification, establishment of subsidiary engineering firms, long-term loans, protection of industrial ownership, subsidies to pioneering firms, and prevention of pirating activities in the case of the textile industry. These factors suggest crucial policy implications on how to manage imported technology for the sake of rapid absorption and diffusion in each industry. How, then, can the findings on absorption and diffusion in the context of economic growth be interpreted?

No doubt, Korea's economic growth over the last two decades has been remarkable in terms of exports and national production. In the sense that investment of material capital and labour was increasingly put into the export sector, it may be argued that a simple Cobb Douglas production function could be applicable in explaining such a high economic growth.

Entering the new development stage, i.e., heavy and chemical industrialization, where resources such as labour, land, and water are scarce, however, economic efficiency at both the firm and national levels becomes crucial, thus requiring ever-higher levels of technology in all aspects.

Nevertheless, Korean technology, imported and indigenous, is not at a sufficient level to simulate the Schumpeterian attributes that Japanese growth possessed. The pattern of

Japan's postwar economic development fits nicely into Schumpeter's model.[2] Although Schumpeter's model is deficient in dealing with many of the detailed and intricate operations of modern Japanese economy, it does come to grips with the essential dynamic undercurrents of Japan's industrial experience.

After all, technological change and capital formation were the major catalytic agents that transformed the postwar Japanese economy with such decisiveness and swiftness. Even the capital formation in Japan originated from the technological progress following the working of what Schumpeter called "creative destruction." Productive activity shifted continually from old to newly installed and more efficient manufacturing facilities in pursuit of high productivity. This creative destruction could only be realized when supported by high technological achievements.

In contrast, the Korean experience diverges from the Japanese experience, particularly after the emergence of heavy and chemical industries in the mid-1970s. The art and techniques in western decoration, furniture, gardening, and construction could be swiftly absorbed and even exported in the form of hard- and software. In heavy and chemical industries, however, the situation was quite different. The degree and speed of technological progress in this field was less satisfactory compared with targets set in the long-run economic development plan.

Summarizing what has been learned about the four manufacturing sectors discussed in the case studies, it can be said that the rate of absorption of imported technology has been quite rapid in comparison with other developing countries. Substantial improvements have also been made in relation to ancillary processes. The rate of diffusion, however, appears to have been slow, as expected, except in the textile industry, where even the export of technology has been accomplished. The rate of assimilation has varied according to the sophistication of the technology concerned, but, except in the iron and steel industry, it has not been slow.

It should be stressed here, however, that the rates of absorption and diffusion are rapid only in minor or "peripheral" technology in connection with construction (civil, housing, underground piping, warehouses, foundations, roads, offices, structures, erection, commissioning), start-up, operation, maintenance, training, procurement, foreign-loan application, detailed design, etc., but in major or "core" technology such as basic design, supply of fundamental facilities, research and development, etc., particularly when the technology involved is highly sophisticated, absorption and diffusion have been trivial.

Based on the findings of the case studies, some policy suggestions related to absorption and diffusion, as well as economic growth, are offered:

(1) The first task confronting Korea is to make a distinction between imported (exogenously available) and indigenous (endogenously created) technologies, and to give priority to the former during the 6th plan period of 1988–1992, even though they are not substitutable but complementary. At present, the import of appropriate technology and its rapid absorption and diffusion are required more, in Korea, than creating domestic innovations. Gradual development of technology, stage by stage, is desirable.

(2) Because the absorption of major core technology was not as rapid as in the case of minor unsophisticated technology, economic targets should be adjusted to levels that the current rate and status of absorption and diffusion will permit. Otherwise, technological dependence will increase and the danger of neo-imperialism might prevail in Korea.

(3) In order to increase the rate and capacity to absorb and diffuse, nonappropriate technology, e.g., so-called "standardized product stage" technology already having entered "the mature or declining stage of commodity life cycle," should not be imported. Instead, technology in "the development or growth stage of commodity life cycle" is desirable. Secondly, an increase in the speed of absorption and diffusion depends mostly on the absorptive and pulling capacity of the economy, in addition to the various factors described earlier. The absorptive and pulling capacity can only be enhanced by the domestic science and engineering activities and negotiating power in importing foreign technology. Domestic activities suggested for Korea are: increase the human capital embodying high technology via proper and efficient education and training, eliminate or diminish administrative red tape, introduce various restrictive clauses and behaviour to technology-supplying firms, and promote technological nationalism to protect or maintain the already widening technology gap.

(4) By improving negotiating power, imported technology has to be unpackaged. For example, Japan has unpackaged petrochemical technology into two components: core and peripheral. The latter was not imported but substituted by domestic engineering firms, whereas core technology was carefully selected and imported. Only the core technology, which is indispensable and

[2] Terutomo, Ozawa. 1974. Japan's technological challenge to the West, 1950–1974: motivation and accomplishment. Cambridge, England, MIT Press.

could not be developed easily, was imported. In Korea, this necessity is much more serious.

(5) In Korea, technology imports have been confined, for the most part, to large firms. The scope and diversification of imported technology, however, must be enlarged to enable small- and medium-sized firms to induce the technology that is appropriate for their industrial uses. The simple techniques adopted by small- and medium-sized firms can be absorbed and diffused much more easily and widely than the sophisticated techniques utilized by large firms. Large firms should diffuse their absorbed technology to small- and medium-sized firms.

(6) Technological change has been far more extensive than the comparatively simple change in the quality of industrial artifacts. It is a sociotechnological phenomenon in which Korean society is totally immersed. Korea's inferior capability to adopt technological change easily and rapidly stems from its culture, the psychology of the people, and the historical momentum of society. In order to achieve recurrent development of major technological changes initiated by innovators and later followed by others in what Schumpeter called "swarmlike appearance," science and engineering mentality should sweep all over the country and people. Social value should change, therefore, toward favouring science and technology.

Comments: V. Kanesalingam

The Korean paper covers four case studies dealing with the (1) petrochemical industry, (2) iron and steel industry, (3) machinery industry, and (4) textile industry.

As the author states in the synthesis report, the objective of the case studies has been to learn as much as possible about the absorption and diffusion of imported technologies from advanced economies. Through a set of common questions and the adoption of a common definition of the terms technology, absorption, and diffusion, the author has attempted to strike a common basis of comparability in the behaviour of imported technology, in relation to the capacity of the Korean industrial system and the environment in which it operates, and indicated by the capacity of this system to absorb and diffuse technology.

The case studies seem to have been inhibited by one major limitation, the fact that it was not a single firm but a number of firms that were concerned with the activities forming part of the technology studied. For instance, the technology required for the design, construction, operation, maintenance, and improvement of a polyethylene manufacturing plant was the concern of more than one firm, which meant that the enquiry into the absorption of the technology had to be carried out in not one but in several firms, i.e., not only the firm producing polyethylene but also the firms producing and installing machinery for its production.

Another problem facing the study was that economic theory did not provide much guidance regarding the study of absorption and diffusion of modern technologies. The enquiry, therefore, had to be guided by "learning-by-doing." The absence of economic theory to guide the enquiry was further complicated by the post-transfer adaptation of technology in the importing country. True absorption of imported technology ought to include any adaptation in the importing country, but the author found that existing economic theory provides little guidance to analyze and evaluate this phenomenon.

The author laments that in studying the diffusion of imported technology, the use of economic theory was limited by the fact that the numbe: of firms within the industry receiving the technology was too few — in many cases it was one large firm — and the absence of a greater number of similar firms meant that a major precondition for diffusion was absent.

In spite of these limitations, measures of both absorption and diffusion are present. Three devices required to measure absorption are cited: (1) the measure of labour absorption reflected by the extent of participation of nationals in the successive phases of absorption; (2) the measure of capital absorption, which is confined to the operating phase only; and (3) unit or average cost as a percentage of some measure of standard cost. The author states that these measures were easy to apply to the studies and were revealing. Although measures could be devised to evaluate the extent and quality of absorption, to measure diffusion one had to look backward to the suppliers of inputs or forward to the customers of the products of the firm. Backward diffusion can be measured, for example, by the extent of substitution with local supplies of plant and equipment forming part of the capital goods of the firm. A similar quantitative measurement of forward diffusion does not exist. What are available are general observations on the flow of technical knowledge to users of the product, students, and the general public.

Petrochemical Sector — The author studied one firm in depth and a few others superficially, the subject of the in-depth study being the Korea

Pacific Chemical Corporation. At the time of the study the Korea Pacific Chemical Corporation was 50% owned by a U.S. firm and 50% owned by Korean citizens. Although there was no Korean government ownership of the single firm studied, the study reveals that the role of the Korean government has been crucial in promoting or enhancing the rate of absorption of imported technology in the petrochemical industry. In fact, the findings of the study show that absorption has been very rapid. The rate of diffusion on the other hand, has been rather slow. The reasons for this are explained in the study.

In contrast to the Sri Lankan situation, this study is quite revealing. Two aspects that differ from the Sri Lankan situation are (1) the industry being a joint venture, facilitated by the "learning-by-doing" process and the rapid absorption of technology and (2) the policy of the Korean government facilitating this process. One also notes from the study that a major factor contributing to the low rate of diffusion of technology in this industry is the low turnover of technical personnel from this firm to other industries or even abroad.

Adaptation of technology is well explained in the study by analyzing and evaluating the measures adopted by the firm regarding raw materials savings and energy conservation.

The presentation of data is quite lucid and another good point in this study is the account provided in it of the policy measures adopted by both the Korean government and the firm to retain the technical personnel developed in the firm, and in this way retain and protect the "know-how" acquired by the firm; and finally to diffuse technology through research projects and consultancy.

On the whole, the case study of the petrochemical sector is balanced, its analysis quite revealing, and findings clearly indicated. The only limitation, a major one, is that the findings are based on the study of one firm, from which the author seems to have no escape.

Iron and Steel Industry — This study reveals a situation different from that related to the petrochemical industry. Pohang Iron and Steel Co. Ltd. (POSCO) is the first integrated steel mill in Korea. Its technology was part of the package relating to supply of capital. The study does not adequately discuss government policy. It is not clear how government policy has facilitated the absorption of imported technology. The lack of information on this aspect is glaring because in the case of the petrochemical industry this has been elaborated on in the analysis.

Another weakness of the study is in its coverage. The author admits that an analysis of the absorption of technology in more than one steel mill is necessary to evaluate more meaningfully the pattern and velocity of absorption and diffusion of the imported technology. This has not been attempted, however. Admittedly, the findings are based on the analysis of a narrow base.

The study refers to the fast absorption and assimilation of imported techniques and attributes it to POSCO's attention, early in its evolution, to the training of its personnel, but it is questionable whether the absorption as depicted in the discussion could be referred to as remarkable. Even on the question of diffusion of technology it seems that the analysis is not adequate enough to allow any meaningful conclusions to be reached.

Machinery Sector — This study presents a situation different from that of either the petrochemical or iron and steel industry. The Daewoo Industrial Co. had changed its corporate form several times between 1937 and its tie with the German firm MAN in 1970. The study concentrates on the period after 1970. An interesting finding of this study is that the absorption of imported technology is highly dependent upon the continuity of the demand for the products of the technology.

The study also highlights the impact of the Saemaeul Movement on the attitude and motivation for import substitution of machinery parts and devising measures to economize on energy and save on raw materials.

The study ends by posing a question that merits further research: Should developing countries opt for simpler technologies that are easier to learn, absorb, and diffuse or for sophisticated technologies that will enhance their competitive capacity in international markets by ensuring a higher quality product? Taken as a whole, this study is a bold attempt to delve into the technological evolution of an industry that has had a chequered history.

Analysis of Systems Behaviour in the Absorption and Diffusion of Imported Technology

Suck-chul Yoon[1]

This paper aims to systematize the major findings from a case study of the absorption and diffusion of imported machinery technology in Korea during the 1970s. A systems approach was used in order to view the whole system macroscopically.

Even though the word "system" has been defined in many ways, all definitions agree that a system is a set of parts coordinated to accomplish a set of goals. Regardless of the definition chosen, one can outline five basic considerations that must be kept in mind when applying a systems approach: (1) the total system objectives and, more specifically, the performance measures of the whole system; (2) the system's environment or fixed constraints; (3) the components of the system, the activities and goals; (4) the resources of the system; and (5) the control of the system. Each of these aspects will be discussed in detail.

System Objectives

An industrial technology is not like an object of art, which can exist by itself. It is merely a "subsystem" of a more comprehensive system, the latter usually a business corporation, which may employ the industrial technology as a means to conduct its business or achieve economic goals. In other words, the objectives of an industrial technology are only viable within the constraints of the more comprehensive system's objectives, which are usually oriented toward economic efficiency.

Thus, it is quite natural to assume that an appropriate industrial technology is determined not only by technological but also by economical dimensions. It is often argued that it is only possible for large-scale, centralized, capital- and energy-intensive technology to exist in a society where a whole host of special conditions are satisfied. Therefore, western technology is inappropriate in underdeveloped countries and western aid should not concentrate on helping underdeveloped countries to acquire the kind of technology developed countries rely upon.

This "appropriateness" issue was considered in the case study under discussion and three hypotheses were set up to investigate its validity:

(1) Western technology is capital intensive, it uses a lot of expensive machinery and little labour.

(2) Western technology depends upon a supply of highly skilled labour of all kinds, from skilled manual workers to managers. This cannot be easily provided by most underdeveloped countries. For this reason, an imported plant is either run inefficiently or else its operation depends upon foreign experts.

(3) Western technology is extremely expensive and its import by an underdeveloped country means a significant drain on foreign reserves. Interestingly, executives and top managers of Daewoo Heavy Industry (DHI) agreed that their diesel-engine technology deserved all of these criticisms.

As for the argument of capital intensiveness, DHI tried to solve the problem by running the plant on a three-shift basis instead of one shift, as originally designed. Because interest rates in Korea were three times higher than in western countries, it was believed that plants erected using borrowed foreign capital should be exploited three times as much.

Regarding the demand for highly skilled labour, this created problems for the company from the outset of its operation, even though manpower employment contracts with the technology supplier alleviated the problem considerably.

Concerning the expensiveness and foreign

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reserve drainage, the company began to face insurmountable financial difficulties and eventually came under the "financial control" of the Korea Development Bank, the company's major creditor. Seeing the situation evolving in this way, the Korean government began to seek a private company that might be competent enough to overcome the managerial and technical predicament into which the company had fallen. Under these circumstances, the Daewoo Industrial Company was chosen and persuaded by the Korean government to take over the ailing company in 1976.

Thus, a conclusion drawn at this stage of the analysis might confirm the hypothesis that large-scale, centralized, capital- and energy-intensive technology is inappropriate for underdeveloped countries and that western aid should not concentrate on helping underdeveloped countries to acquire the kind of technology developed countries rely upon. Further study, however, revealed that some environmental changes, either by chance or by governmental action, can play a decisive role in changing the entire behaviour of a technological system.

Environments and Their Impact

The environment of a system is what lies outside of the system. This is not an easy matter to determine because not only is the environment something that is outside the system's control, but it is also something that determines, in part, how the system performs. In the case of an industrial firm, sales demand lies within the environment of the system because its nature influences system performance.

In 1975, there were three major automobile manufacturers in Korea, each of them reluctant to use domestically produced engines. There were several reasons for their reluctance. Firstly, they had no confidence in the quality of domestic engines. The manufacturers were already having enough problems with the quality of many other automobile parts that were being supplied domestically. Secondly, there were either insufficient or negative price incentives to use domestic engines. This surprising phenomenon came about for the following reasons:

(1) Due to restricted market size, "economy of scale" in production was not achievable.

(2) Most parts and raw materials were imported from abroad at a higher cost because the quantity ordered was not large enough (also due to small market size) to qualify for a cheaper price; also, most buyers were in a captive position.

(3) Due to financial infirmity, production facilities were usually bought through foreign or domestic loans, thereby resulting in heavier interest burdens.

(4) Costs incurred as a result of technical inexperience and lack of management know-how were transferred to the price of the products. For these reasons, domestic machinery products were more expensive than imported goods.

In an environment with this kind of confidence gap and negative price incentives, the engines produced by the Hanki Corporation in 1975 could not find their way onto the market and the diesel-engine project fell into financial difficulties. Hence, personnel who were employed in the diesel-engine project were transferred to other projects, either voluntarily or involuntarily. The company could not afford to keep highly paid technical personnel working on a project when the project was losing money due to a lack of market demand for the products produced. Without the continuity of demand for the products, it was not possible to retain those employees engaged in the technical activities of production. This, in turn, rendered the continual absorption and accumulation of technical knowledge in the area torpid or even backward.

This case study proposes, therefore, that the rate of absorption of an imported technology is heavily affected by an environmental factor — the nature of demand for the products the technology produces.

Encouraged by the Korean government, Daewoo Industrial Company bought the controlling portion of Hanki Corporation's equity. The first major step Daewoo Industrial Company took was to ask the Korean government to impose a ban on the importation of diesel engines from foreign countries. The Korean government accepted the appeal on the condition that the price of the diesel engines produced by Daewoo Industrial Company would come under the control of the government.

During the latter half of the 1970s, the Korean economy, on the whole, grew at more than 10% annually, and real industrial growth averaged about 30% per annum. Accordingly, transportation requirements rose rapidly during the same period and shortages of trucks and buses began to emerge.

If it can be assumed that the steady approach of the rate of output to the designed capacity and the decreasing rate of defective items are quantifiable indicators of the rate of absorption of an imported technology, Table 1 can be used to corroborate the hypothesis that manufacturing know-how and related technical activities are steadily absorbed and accumulated in a company

Table 1. Diesel-engine output, 1975–1978.

	1975	1976	1977	1978
Design capacity	24000	24000	24000	24000
Actual production[a]	1120	2578	9385	15206
Sales	285	3119	9313	15041
Defective (%)	30.78	27.15	20.45	15.42

[a]Actual production figures = gross production − defective items.

as the market demand for the products produced using the imported technology becomes stable and steady. However, for the technological breakthrough to be achieved in this case, environmental or market changes were not solely responsible; there were many other interrelated problems to be cleared up, problems resulting from the fact that a technological system is comprised of a multitude of subsystems that are interrelated with each other.

Interrelationships among Subsystems

A major technical problem encountered from outside the system boundary was to mount the MAN (Machienenfabrik in Augusburg und Nürnberg) engines in buses and trucks that were being manufactured by the three major automakers. Engines are not final products by themselves, i.e., an engine is a subsystem of a larger system. There always exists a certain degree of interrelationship between a subsystem and its global system. Hence, for an engine to be mounted in a vehicle, some technical problems to integrate the two into a total functioning system must be worked out unless the two were initially designed as a system. However, because Korean automobile manufacturers were already producing trucks and buses with imported engines up to 1975, technically, it was not immediately possible for the MAN engines to be mounted in the vehicles that were being produced. Considering that the licencing agreement did not contain or mention anything about this kind of adaptation problem, it was, apparently, a mistake on the company's part not to have considered that this kind of problem might occur.

After taking over the company, Daewoo Industrial Company launched a project to solve the mounting difficulty. Firstly, Daewoo Industrial Company's project team worked in close contact with the Korea Institute of Science and Technology (KIST), a research institute established by the Korean government to help business industries solve technology-related problems. In addition, Daewoo Industrial Company asked MAN for assistance. In the beginning, MAN was reluctant to provide extra assistance that was not included in the licencing agreement. However, at Daewoo Industrial Company's repeated and earnest request and after having learned about the seriousness of the barrier to the market due to this mounting difficulty, MAN began to help by providing technical information and assistance to solve the adaptation problem. After almost a year's struggle, the problem was solved satisfactorily.

The quality level of a technological system is determined by the lowest quality level that a subsystem of the system attains. This system relatedness, between the global system and its subsystems, is responsible for the diffusion of technology to other firms supplying parts. In recognition of this, Daewoo Industrial Company launched a program, in line with governmental directives, to assist small parts-manufacturing firms by providing technical know-how combined with financial support, a quasi-forced diffusion! This program started noticeably in 1976 and achieved considerable success not only in localizing materials and parts but also in enhancing their quality level.

Resources of Industrial Technology

Resources are the general reservoir out of which the specific actions of the system can be shaped. The specific actions a business corporation can take regarding its industrial technology are to import foreign technologies, adapt them to their specific needs, diffuse them voluntarily or involuntarily, or develop their own technology. During the course of this case study, it was found that even though the localization and quality enhancement program discussed earlier succeeded insofar as to contribute significantly to production-cost reduction and foreign currency savings, foreign dependence was still significant, particularly in the area of engineering design. "Engineering design," remarked a chief engineer who had been engaged in the diesel-engine project at DHI, "requires, as it were, 'know-why,' if manufacturing products as already designed in the blueprints provided by the licencing agreement could be said to require what they call 'know-how'."

According to this explanation, manufacturing know-how could be incorporated in manuals, blueprints, or other forms of documents with relative ease, whereas know-why can only come from the general reservoir of basic sciences in which developing countries are normally weak.

i.e., the general knowledge of basic sciences, which is needed to understand the basis upon which numerical data, mathematical dimensions, and geometrical configurations are calculated, selected, and decided upon, cannot be concentrated in a neat container, to be transferred from an advanced country to a developing country. This kind of know-why barrier was felt so seriously when DHI tried to add a couple of new models to their production line that they had to make another licencing agreement with a Japanese diesel-engine maker in 1977 as a result. On the other hand, it cannot be assumed that firm-specific technology, which can give a firm a real competitive edge in international markets, is normally not accessible to developing countries. Foreign technologies, which developing countries can buy from advanced countries, however, are likely to be restricted to a narrow spectrum of system-specific technologies.

Thus, the following hypothesis can be drawn concerning resources for developing countries to rely upon for their technological development: Even though the know-how portion of system-specific technologies may constitute resources for developing countries to utilize, the know-why level and internationally competitive firm-specific technologies are generally not transferable from advanced countries to developing countries.

Management or Control of the System

The management of a system deals with the generation of plans for the system, i.e., consideration of the overall goals, environment, utilization of resources, and components. Not only does the management of a system generate the plans of the system, but it must also make sure that the plans are being carried out in accordance with its original ideas. If they are not, management must determine why they are not. This activity is often called control of the system.

Goals of the System

From the standpoint of a developing country, one of the most important goals of its industrial technology systems is to import foreign technologies and absorb and diffuse them within the nation to build up technological capabilities. In addition, a developing country normally has another goal to pursue — to manufacture products utilizing imported technologies and to sell them in the international markets in order to earn foreign currency.

These goals, however, can easily conflict with each other. If a developing country wishes to pursue the goal of learning, absorbing, and diffusing imported technologies, it should start with simple technologies because simple technologies are believed to be easier to learn. On the other hand, when developing countries hope to produce products that will be competitive in international markets, the requirements of product quality (of which precision, standardization, and consistency of manufacturing process are primary determinants) demand importation of techniques that are usually sophisticated with specialized automation and numerical control mechanisms. These sophisticated technologies are believed to be much harder to learn than simpler technologies.

Hence, the importation of sophisticated technologies in order to be competitive in international markets could frustrate the process of learning, absorbing, and diffusing imported technologies. To the extent that this reasoning is valid, the following conclusion can be drawn: A developing country should strategically choose between two extreme policy alternatives: one is to emphasize being competitive in international markets in the short run and the other to build up technological capabilities as a long-term goal.

The Environment

In most developing countries, firms cannot support highly-paid technical manpower in money-losing projects. Therefore, if the demand for the merchandise produced using imported technologies is not secure, it is not possible to retain those people engaged in the technical activities of production. Furthermore, this results in the breakdown of absorption and accumulation of technological knowledge. Hence, in order for a developing country to secure continuous and sound absorption of imported foreign technologies, governmental control over the degree of competition among firms using similar technologies is needed. This could be accomplished by restricting the number of approvals to import foreign technologies of a similar kind so that competition might not be too excessive for the market size.

Excessive competition among firms using similar techniques also affects the diffusion of technology. The case study revealed that the diffusion of technologies took place through engineers who moved to other competing firms to obtain promotions and higher salaries. This kind of manpower robbery may contribute to the diffusion of technologies in the short run, but it

proved to be detrimental to the sound accumulation of technologies at the firm level. In a developing country, sound absorption and accumulation of technologies should be the first priority, after which healthy diffusion may be possible.

In recognition of the need for environmental control policies, the Korean government resolved to force major firms competing excessively in the field of automobiles, power-generating facilities, heavy electrical equipment, etc. to merge in 1980.

Resources

Superficially, the fact that underdeveloped countries tend to get all, or nearly all, of their needed technologies from foreign sources may look like the rather obvious result of a particular aspect of the comparative advantage theory of world economics. However, if an economy that is short of particular skills or technologies continuously relies upon external sources of technical knowledge, the opportunities to nurture domestic resources, such as scientists, engineers, technical managers, and technicians, are very likely to be narrowed. This will be particularly true when the transfer process is packaged. Hence, efforts by a developing country to "unpackage" the transfer process will doubtlessly be conducive to raising domestic technological resources through the learning-by-doing opportunities offered during the unpackaging process.

There are, however, some problems with the unpackaging transfer process. The first is a financial problem. Unpackaging the transfer process involves risks. If the size of the financial risks involved seems too great for the technology-importing firm to bear, the unpackaging decision will be difficult. Normally, business firms in developing countries are not financially strong enough to undertake unpackaging the transfer process.

The second problem is of a technical nature. Unpackaging itself takes a certain degree of know-how. When the firm importing technology from an advanced country is ignorant of the technology, the firm will likely be ignorant about methods to unpackage the process. Unpackaging is, therefore, not possible for technology-importing firms until they reach at least a minimum level of technological capability to unpackage the transfer process.

These problems constitute barriers to the desire to unpackage the process of technology transfer from the standpoint of developing countries. In particular, they created difficulties for engineering firms in Korea during the 1970s.

Interrelationships among Subsystems

The gains from learning-by-doing are normally external economies as far as individual enterprises in the developing country are concerned, i.e., the enterprise itself, which makes the decision to purchase domestic skills, may not benefit from the skills and experiences developed and accumulated in the country due to this decision. Thus, the individual private enterprise left to itself in the world technology market will attach little importance to building up local technological capabilities, i.e., private companies are apt to pursue suboptimization as long as the state government does not interfere in the market to produce nationally optimal results.

Similarities and Differences: The Indonesian Case

Nilyardi Kahar[1]

The study group at this workshop is mainly concerned with the absorption and diffusion of imported technology (ADIT) at the firm level. The study has concentrated on the textile sector. The bottom-up approach has been adopted to draw conclusions at a macro/national level.

The Indonesian group has not made a detailed study at the firm level yet. At the moment, one ongoing study is concerned with science and technology policy and instruments research at the macro level. The methodology being adopted for this particular study is taken from an earlier IDRC study.[2] There are also plans to undertake a specific sectoral study, i.e., in the textile and electronic industries. The study will look at the kinds of science and technology policies and instruments that can be used to strengthen the many aspects of these sectoral industries.

Large-scale development of industries in Indonesia started in 1969 (i.e., the beginning of the first 5-year development program, PELITA) and covered many sectors. The economic situation up to that time (1965–1969) was very weak, after a drastic change in the political situation in 1966. The population problem is the most dynamic factor in the national development of Indonesia and is characterized by: a fast rate of growth (the total population currently is about 140 million, with a yearly growth rate of more than 2.2%); unproportional distribution (more than 60% of the population lives on the island of Java); migration from rural to urban areas; and a large percentage of young people.

In the first PELITA program, the government opened the door for foreign capital. Lack of capital but the presence of natural resources enabled the government to encourage foreign investors to develop industries in Indonesia. The process of importing technology in many sectors, therefore, began on a large scale. The main targets of the government at that time were: to fulfill the basic needs of the people, and increase national income and foreign exchange so that further development programs could be conducted.

The growth of the economy has put the government in a position to begin selecting more appropriate technologies, which will be imported to strengthen the further growth of industries. Several general criteria have been set up by the government for the import of technologies. The technologies must assist in: increasing national development, creating new employment, increasing the utilization of local raw materials, increasing domestic professional skills, encouraging "in-house" activities, increasing export commodities, developing other cooperative efforts, developing domestic and regional markets, increasing import substitution, encouraging research and development capabilities, and preventing a negative impact upon natural resources and the environment.

In Indonesia, as in other developing countries, the role of the government in the development of industries and transfer of technology is dominant. Several institutions at high levels are involved in the assessment of the import of technology, which sometimes conflicts with policies.

The increasing average income of the community has raised the demand for better quality goods. This condition stimulates industries to improve technology and increase absorption and assimilation of technology at the firm level.

Before the time of large foreign investment in Indonesia, the textile industry already existed in small-scale and traditional industries. Initially,

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[2]International Development Research Centre (IDRC). 1975. The science and technology policy instruments (STPI) project. Ottawa, Canada, IDRC, IDRC-050e, 12p.

the target of large investment through the import of technology related to textile industries was to fulfill the local basic needs of the community. The growth of the industry was based on several kinds of technology, which were biased toward the origin of the capital investment.

Now, the textile manufacturing industry has reached its target of meeting national consumption needs and is able to export. The government has put some restrictions upon the foreign investment of further kinds of industries and also on the import of textiles. The growth of this industry is directed toward strengthening the industry so that it can produce raw materials for textiles.

Small-scale local industries have now reached a stage where they can survive and most of them are shifting into the production of specific traditional and art articles. A new kind of indigenous industry, i.e., the confectionery industry, is now growing in Indonesia and is able to export its product.

The role of the Indonesia Textile Institute of Technology in the absorption, assimilation, and diffusion of textile technology is great. One of the general problems related to the rate of absorption and diffusion of imported technology in Indonesia is the shortage of qualified skilled and educated manpower. Although the output of various universities and training institutes is increasing, the need for qualified manpower still cannot be met due to the rate of growth of industries in many sectors. Education is one of the keys toward improving the absorption and diffusion of imported technology in the long run.

Industries in Indonesia do not use, as yet, their local supply of science and technology to its maximum capability. It is an extra effort for the local supply side of science and technology to develop linkages with industries.

Concerning this workshop and the interests of Indonesia, there are some questions to be raised:

(1) What are the common indicators that should and can be measured to determine the status of absorption and diffusion of imported technology at the firm level and for the textile industry and how can they be extrapolated to draw conclusions at the national level? Is it possible to have a common and general methodology to study absorption and diffusion of imported technology in the textile industry?

(2) It seems that the role of manager/entrepreneur is important for the success of absorption and diffusion of imported technology at the firm level. Is it possible to formulate a checklist/manual that could be used to guide the manager in making a technological decision?

(3) Is there any way to measure/assess the degree of sophistication of "an imported technology" relative to "local technological capabilities"? If there is, what about the critical technology gap that can ensure the absorption and diffusion of imported technology process effective?

Japanese Investments in South Asia from a Global Perspective

W.D. Lakshman[1]

The disruption caused by World War II to the economy of Japan was enormous and economic activity fell to the level of 30 years earlier (Ohkawa 1979; Ohkawa and Rosovsky 1973). Through abnormally high rates of growth immediately following the war, Japan was able to complete its economic recovery and rehabilitation by the mid-1950s. During the subsequent period, described as the period of normal postwar growth, the Japanese economy grew very rapidly (Patrick and Rosovsky 1976). This rapid economic growth and related development resulted in Japan playing an increasingly important role in the sphere of international economic cooperation.

Active participation by Japan in this international role, however, was delayed until the latter part of the 1960s. This is generally attributed to the balance of payments difficulties the country was subject to until that time in spite of, or perhaps partly as a result of, its rapid economic growth. Japan's experience as a large investor abroad as well as a large aid donor, therefore, has a short history, with the exception of a few large-scale (foreign) projects in which the government has participated (Sekiguchi et al. 1977). Direct investment abroad, in particular, remained very small until the late 1960s. In addition to weak balance of payments, low levels of managerial capability (by international standards) and the prevalence of abundant labour and low wage levels, until the mid-1960s, were also responsible for the country's low profile in foreign investment (Sekiguchi et al. 1977). It was only in 1964 that Japan joined the Organization for Economic Cooperation and Development (OECD).

These were probably responses of policy-makers to certain underlying economic phenomena that made private investors seek foreign investment locations. Other economic phenomena included gradual increases in Japanese wage levels and land prices, yen revaluation, increasing pressure for stable supplies of materials to feed domestic industries, tightened environmental restrictions on domestic manufacturing firms, and gradual reduction of tariff and nontariff barriers on imports coming into Japan (Yoshihara 1978; Sekiguchi et al. 1977; Krause and Sekiguchi 1976).

The rapid growth of Japanese investments abroad did not take place uniformly in different regions and countries of the world. South Asia, for example, was one of the low-priority areas for private investment. As if there were a deliberate attempt to compensate for the low level of Japanese direct investments in South Asia, however, a relatively larger flow of official development assistance was directed toward the region. Still, South Asia remains, even in terms of total (public as well as private) Japanese resource flows, a relatively low-priority area.

The purpose of this paper, therefore, is to look at Japanese investments in South Asia in relation to not only total Japanese private investments but also total resource flows from Japan into underdeveloped countries (UDCs).

Total Resource Flows to Underdeveloped Countries from Developed Countries and Japan's Role

Since World War II, the problems of UDCs and the widening gap between them and developed countries (DCs) have become an issue of international concern. The transfer of resources from DCs to UDCs has come to be considered as an essential ingredient in the global strategy for

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reducing this gap. In the 1950s and early 1960s, concessional official flows or what has come to be known as "foreign aid" was believed to be the prime vehicle through which these resource transfers could be effected. During this period, foreign aid increased rapidly and by the early 1960s came very close to 1% of the gross national product (GNP) of the noncommunist developed countries (Pearson Report 1970). The overall results of this massive transfer of funds to UDCs, however, was not encouraging. Due partly to developments in both developed and underdeveloped countries, the late 1960s witnessed a decline in international support for development through foreign aid and the very purpose of aid and its feasibility to promote development began to be questioned in both UDCs and DCs.

The disillusion with foreign aid continued into the 1970s. Official development assistance (ODA) flows from OECD countries increased rapidly during the Second Development Decade but their growth lagged behind the GNP growth of donor countries. From 0.51% of donor GNP in 1960, ODA flows decreased to 0.34% in 1970 and remained at that level throughout the decade (Table 1). Most of the growth of ODA at current prices, moreover, was swallowed up by sharp price increases, which were characteristic of the 1970s.

Within this poor global performance of ODA, Japan maintained its ODA flows at an average proportion of 0.23–0.24% of its GNP. Because Japan's rate of growth during this period was, generally, more rapid than that of most other OECD countries and also because the latter's contributions to ODA as a proportion of their GNP declined, Japan's share of the total ODA from OECD countries increased sharply between 1965 and 1979. Growth of its economic power, particularly from a balance of payments point of view, seems to have enabled Japan to maintain its role in development assistance at an undiminishing rate during a period characterized by an economic crisis in the capitalist world.

Although ODA flows from the developed to the underdeveloped world increased, albeit slowly, the needs of underdeveloped countries for external financing grew more rapidly. As indicated in Table 2, total net resource flows into UDCs increased more rapidly than concessional flows of ODA. The share of ODA in total resource flow declined between 1970 and 1978. The most rapid growth occurred in resource flows via portfolio investment and "other" nonconcessional flows, in which short-term export credits occupy a major position. Given the negligible share of portfolio capital at the beginning of the decade, its contribution to UDC resource needs even in 1978 was a mere 4%, despite its relatively faster growth over the period.

Due to the growing disillusion with official foreign aid, in the late 1960s, most industrialized countries were advocating that private investment could and should replace official aid flows (Pearson Report 1970). Although the Pearson Commission considered this extreme position as an illusion under the then existing state of affairs, they nevertheless placed heavy reliance upon foreign private investment in UDCs as a useful complement to aid and recommended various measures to increase private direct capital flows into UDCs. Although there was a "massive" expansion (OECD 1979) of total private capital flows into UDCs, the expansion in private foreign direct investments into those countries was of moderate magnitude. The share of such investments in total net resource flows into UDCs registered a slight decline from an average

Table 1. Net flows of official development assistance from OECD member countries and Japan, 1960–1979.

	All OECD countries			Japan		
Year	Total ODA ($ million)	ODA as % of donor GNP	ODA at constant (1978) prices[a] ($ billion)	ODA ($ million)	ODA as % of GNP	Japan's share of total ODA from OECD countries (%)
1960	4628	0.51	13.1	105	0.24	2.27
1965	6478	0.49	16.7	244	0.27	3.77
1970	6967	0.34	14.9	458	0.23	6.57
1975	13820	0.36	17.9	1148	0.23	8.31
1976	13829	0.33	17.3	1105	0.20	7.99
1977	15680	0.33	18.0	1424	0.21	9.08
1978	19994	0.35	20.0	2215	0.23	11.08
1979	22267	0.34	20.1	2638	0.26	11.85

[a]The price index used is the U.S. dollar GNP deflator based on price increases in OECD countries measured in terms of U.S. dollars. It takes into account parity changes between U.S. dollars and national currencies.

Source: World Bank, 1980. World Development Report, 1980.

Table 2. Total net resource receipts of developing countries from all sources and their composition, 1970–1978.

	Total net resource receipts (U.S.$ billion)	Percentage distribution of total net resource receipts			
		ODA	Direct investment	Portfolio	Other non-concessional flows
1970	18.86	41.8	20.6	1.6	36.0
1971	20.51	43.4	16.1	1.5	39.0
1972	22.45	42.6	18.7	2.2	36.5
1973	30.73	37.7	15.4	2.3	44.6
1974	32.97	46.2	3.4	1.2	49.2
1975	52.58	37.1	20.0	0.6	42.3
1976	55.07	34.2	14.2	2.0	49.6
1977	61.66	32.1	14.2	3.7	50.0
1978	78.39	28.7	14.6	4.2	52.5

Source: OECD (1979).

Table 3. Total recorded net flow of resources from Japan to UDCs and multilateral agencies: its share of total flows from DAC countries and its composition, 1970–1978.[a]

	Total resource flow from Japan (U.S.$ million)	Total resource flow from Japan as % of total resource flow from DAC countries	Composition of total resource flow from Japan (%)			
			ODA	Direct investment	Portfolio investment	Other non-concessional flows
1970	1823.9	11.5	25.1	14.3	1.2	59.4
1971	2140.5	11.9	23.8	10.4	12.1	53.7
1972	2725.4	13.7	22.4	7.5	31.5	38.6
1973	5844.2	23.7	17.3	22.3	32.6	27.8
1974	2962.3	10.6	38.0	23.8	6.2	32.0
1975	2890.0	7.2	39.7	8.1	1.6	50.6
1976	4002.6	9.9	27.6	27.1	3.6	41.7
1977	5534.9	10.9	25.7	13.1	15.0	46.2
1978	10703.6	15.4	20.7	12.3	42.8	24.2

[a]Because the raw data are from a number of reports, comparability of the data series, year-to-year, may not be perfect.
Source: OECD. Development co-operation. Various annual reviews.

of 18% in 1970–1971 to an average of 14% in 1977–1978 (Table 2). These direct investment flows were, moreover, distributed unequally between UDCs at different levels of economic development.

Total net resource flow from Japan into UDCs appears to have increased more rapidly than total net resource flows from all of the countries of the Development Assistance Committee (DAC) of the OECD. There were sharp ups and downs in Japan's share of the total between 1970 and 1978 (Table 3).

There were both similarities and differences in the changes in composition of these total flows from DAC countries, on the one hand, and Japan, on the other. As in the case of total DAC flows, the ODA proportion has also declined in Japan. The phenomenal increase in the share of portfolio investment in Japanese resource flows to UDCs is noteworthy, but it is not possible to judge from available data whether or not the 43% share of portfolio investment for 1978 was a random event or is indicative of future possibilities. It may also be noted that, in contrast to conditions in the rest of the OECD countries, the increase in "other" nonconcessional flows from Japan occurred at a lower rate of growth than Japan's total resource flow, thereby reducing its share of the total.

Dependence upon foreign financing for economic development is undesirable, the main objective being development through domestic efforts. Most underdeveloped countries depend heavily upon foreign resources either because their domestic effort is inadequate or because, despite strong domestic effort, forces beyond their control make dependence upon foreign resources imperative, at least in the short run. In either case, the success of their development effort would be heavily dependent upon the total

Table 4. Net bilateral flows of capital from Japan to UDCs in the form of ODA and nonconcessionary flows, 1973–1978.

	ODA		Nonconcessionary flows[a]		Bilateral total
	U.S.$ million	%	U.S.$ million	%	U.S.$ million
1973	765.18	15.0	4336.14	85.0	5101.32
1974	880.37	32.5	1830.12	67.5	2710.49
1975	850.40	33.2	1710.57	66.8	2560.97
1976	752.95	21.5	2750.92	78.5	3503.87
1977	899.25	19.8	3636.40	80.2	4535.65
1978	1530.97	17.1	7416.78	82.9	8947.75

[a] Private and other official flows.

Source: Ministry of International Trade and Industry (MITI). Keizai Kyoryoku no Genjo to Mondaiten. Issues for relevant years.

flow of resources from developed countries and their distribution between the recipient countries. These are matters generally beyond the control of the countries receiving aid. This is shown in the Japanese experience of the 1970s. In 1974 and 1975 Japanese resource flows to UDCs were low because it was during this period that the international oil crisis had its worst effects on the domestic economy of Japan. Throughout most of the 1970s, Japan's growth rate was in the 5–8% range, with 1970 and 1973 recording rates of over 10%. In 1974, however, the Japanese economy recorded a negative growth rate of −0.5% and in 1975 its growth rate, though positive, was very low at 1.4%. The trade surplus declined by 59% in 1973 and by another 61% in 1974. Although it increased in 1975, it remained low in relation to most years of the 1970s. Current account of the balance of payments turned from large surpluses between 1970 and 1972 to deficits between 1973 and 1975. These adverse developments, following the oil crisis, had strong adverse effects upon Japan's private and official flows to UDCs in 1974–1975. The same oil crisis that brought about these reductions would also reduce the purchasing power of those resources transferred. This would have a destabilizing effect on countries depending heavily upon Japanese resource flows.

Following the global pattern, the bulk of bilateral resource flows from Japan take the form of nonconcessionary loans and direct investments (Table 4). Because these are mostly from private sources, they are more sensitive to vicissitudes of domestic economic activity (compare 1974–1975 with other years in Table 4).

Table 5 analyzes the broad regional distribution of these bilateral flows. The bulk of the total net flows from Japan bilaterally to UDCs goes to Asia and (Central and South) America. Although ODA, which generally forms less than 20% of the total, goes in bulk to Asia, nearly 80% of the nonconcessionary flows are received by

Table 5. Percentage of net bilateral resource flows from Japan to UDCs: regional distribution, 1973–1978.

	1973	1974	1975	1976	1977	1978
Official development assistance						
Europe	3.0	2.6	0.6	1.6	0.5	0.1
Africa	2.6	5.2	13.0	10.7	17.0	18.6
Asia	88.2	86.9	79.0	78.7	72.3	71.0
America	4.6	4.5	5.6	6.6	8.8	8.6
Other	1.6	0.8	1.8	2.4	1.4	1.7
Nonconcessionary flows (private and other official flows)						
Europe	3.0	0.6	0.4	4.9	12.0	4.1
Africa	8.5	16.5	17.4	16.5	24.4	20.7
Asia	33.6	33.1	56.9	57.4	34.2	40.3
America	53.4	49.6	24.8	20.8	29.2	34.6
Other	1.2	0.2	0.5	0.4	0.2	0.3

Source: Ministry of International Trade and Industry (MITI). Keizai Kyoryoku no Genjo to Mondaiten. Various years.

Asia and America combined. The pattern of distribution of resource flows from DCs to UDCs is generally known to be determined not by matters of "need" but by other considerations. This appears to be true in the case of Japan.

Japanese Direct Investments Abroad: Trends and Patterns

Total private foreign investment flows in the world increased rapidly during the recent past, bringing about an increase in available world foreign capital stock. The share of these annual private direct capital flows invested in UDCs, however, remained low. The position taken by the Pearson Commission in 1970, and reiterated by the Group of Eminent Persons invited by the United Nations to study the impact of multinationals on development and international relations in 1974 (United Nations 1974), that private foreign investment is not a substitute for foreign aid, has been vindicated by actual

developments of the 1970s. It is instructive to examine the Japanese experience in the field of direct investments abroad, particularly in South Asia, within this broad global framework.

The weaknesses and limitations of available data on direct overseas investment flows and foreign capital stock are well known (e.g., United Nations 1978) and one has to be cautious about the type of conclusion drawn from the analysis of available global data. Particularly noteworthy in the present context is the fact that the trends and patterns one would observe in these data may be distorted to some extent because the U.S. dollar, upon which available data are based, has been depreciating markedly in the recent past. In the case of countries whose currencies appreciated in foreign exchange markets vis-à-vis the dollar, the stock of foreign capital in dollar terms would have increased even without any additional new net investment on their part. This is particularly true in the case of Japan because the Japanese yen has been one of the most rapidly appreciating currencies in the world recently.

The stock of total direct investments abroad expanded rapidly during the 1970s — roughly at the same rate as the GNP of developed market economies. Direct investment stock as a proportion of the GNP of DAC countries remained almost constant at 7% between 1967 and 1976 (United Nations 1978). Growth of foreign operation of Japanese business was more rapid in relation to world totals. The Japanese share in the total world stock of direct investments grew from 1.4% in 1967 to 6.7% in 1976 (Table 6). Its annual flow of private investment abroad, at 2% of the world total between 1967 and 1969, rose to 7% between 1973 and 1975 (Table 7). This rapid growth in Japanese foreign investment was the result of the rapid growth of its economic power. The fact that the growth of direct investments abroad took place during this period from a rather low base, and that foreign exchange realignments of the period would also have introduced certain distortions, should not be ignored in interpreting the data presented.

"Transnational corporations . . . have long tended to come from developed countries and to concentrate their foreign expansion within other developed countries . . . seek out and flourish mostly in foreign markets that most resemble the home markets for which they first developed their products and processes . . . the global phenomenon of transnational corporations has been and apparently remains a phenomenon of developed markets" (United Nations 1978, pp. 39–40). In stressing the implication of these trends and patterns in the growth of private

Table 6. Stock of direct investment abroad of developed market economies and Japan's share, 1967–1976.

Year	World total (U.S.$ billion)	Japan's contribution (U.S.$ billion)	Japan's share of world total (%)
1967	105.3	1.5	1.4
1971	158.4	4.4	2.8
1973	198.8	10.3	5.2
1975	258.9	15.9	6.1
1976	287.2	19.4	6.7

Source: United Nations (1978).

Table 7. Direct investment outflows[a] from developed market economies and Japan's share.

Period	Total outflow (U.S.$ million)	Japan's contribution (U.S.$ million)	Japan's share of total outflow (%)
1967–1969	9101	183	2.0
1970–1972	14744	479	3.2
1973–1975	26256	1847	7.0

[a]From balance of payments data.
Source: United Nations (1978).

foreign investment (PFI) for the UDCs, which seem to rely heavily upon PFI as a vehicle of growth, it is worth discussing certain peculiar Japanese trends in the field of PFI.

Using available balance of payments data, the United Nations (1978) study showed that of the total direct investment outflow from developed market economies, 55% on the average had gone into developed countries themselves between 1973 and 1975. The relevant average proportions between 1967 and 1969 and 1970 and 1972 were 61 and 60% respectively. It is interesting to compare the regional distribution patterns emerging from an analysis of relevant Japanese data. The information used for this purpose (Table 8) is not comparable to that used to derive the global proportions, the Japanese data used being based on investment approvals and not on actual outflows. Conclusions derived from the following analysis are, therefore, subject to comparability limitations of the data used.

The total number of foreign investment projects approved had increased threefold from fiscal year 1970 to fiscal year 1978. The corresponding increase in the value of approved investments was fivefold over the same period. Thus, the average investment per project increased, showing the impact of inflation and also, perhaps, the growing size of average Japanese investment projects abroad. At the beginning of the decade, 60% of the projects and 30% of the

Table 8. Japanese private direct investments in developed and underdeveloped countries: number of projects and value of investments approved, 1970–1978.[a]

Financial year (April–March)	Total		Developed countries		UDCs		Proportion of direct investment in UDCs (%)	
	No. of projects	Value (U.S.$ million)	No. of projects	Value (U.S.$ million)	No. of projects	Value (U.S.$ million)	In terms of projects	In terms of value
1970	730	904	292	635	438	268	60.0	29.6
1972	1774	2338	866	1355	908	986	51.2	42.2
1973	3097	3494	1429	1359	1668	2136	53.8	61.1
1974	1910	2395	797	774	1113	1622	58.3	67.7
1975	1592	3280	740	1340	852	1940	53.5	59.1
1976	1652	3462	792	1183	860	2280	52.0	65.8
1977	1761	2806	907	1063	854	1743	48.5	62.1
1978	2395	4598	1335	1778	1060	2821	44.2	61.4

[a]Investments in DCs include those made in the following countries, which are specified in the source: USA, Canada, U.K., Germany, France, The Netherlands, USSR, Belgium, Switzerland, Australia, and New Zealand. Investments in UDCs are the residual from the total. The UDC investments, therefore, are different from those reported in Ministry of International Trade and Industry (MITI), Keizai Kyoryoku no Genjo to Mondaiten. The latter's data pertain to net investments made during calendar years. Components do not always add up to totals because of rounding.

Source: Toyo Keizai, 1980, Kaigai Shinshutsu Kigyo Soran (Japanese multinationals: facts and figures), 1980.

investments involved were approved for UDCs. The corresponding proportions changed to 44 and 61%, respectively, by 1978. Fewer and fewer projects drawing more and more investment funds were approved for UDCs. Projects of gradually increasing size and, perhaps, gradually increasing capital intensity seem to have been attracted by UDCs from Japan.

According to the global data presented, only about 45% of total world PFI had gone to UDCs between 1973 and 1975. The relevant proportion for Japan for the same period averaged 63%. At a point in time, therefore, the proportion of Japanese investments in UDCs seems to have been higher than the corresponding global proportion. In terms of trends in the ratio of foreign investment flows going into UDCs, the experience of Japan in the 1970s seems to have corresponded with relevant global trends.

In spite of the increase in global PFI flows to UDCs, their share of PFI stock seems to have declined in the 1970s. According to the United Nations (1978) report, the UDCs' share of PFI stock in 1967 was 31%, 28% in 1971, and 26% in 1975. Although annual new additions were going, marginally, more into UDCs, the annual appreciation of existing capital stock in DCs (which was initially very large in relation to that of UDCs) seems to have swamped the effects of the relative increase in the annual flow on the pattern of distribution of end-of-period capital stock.

The share of Japanese capital stock held by UDCs seems to be much higher than the corresponding global share. If the accumulated total of investment approvals granted between 1951 and 1978 is taken as representing existing Japanese capital stock in foreign countries (Table 9),[2] the UDCs' share (59% in 1978) in this stock can be seen to have been much higher than the DCs' share in total world PFI. The initial phase in Japan's brief history of overseas expansion of Japanese capital concentrated heavily upon investments in natural resource development. These investments continued to expand rapidly in the 1970s. Given the relatively poor resource endowment of Japan and the sharp increase in demand for resources as a result of rapid postwar growth, the tendency toward rapid expansion of overseas investments in natural resource development was understandable (Sekiguchi et al. 1977). This, in part, explains the dominance of UDCs in Japanese overseas investment, e.g., the bulk of these resource development investments went to the Middle East, Central and South America, and Africa. Having been a latecomer in industrial and technological development, a fair proportion of the manufacturing industries established abroad in the early phase of Japanese overseas expansion was labour intensive. The preferred location for these industries, in which Japan lost comparative advantage with its rising wage levels, was, again, the labour surplus economies of UDCs. From the trends in the regional distribution of annual outflows of

[2]This accumulated total is only an approximate figure for existing capital stock. It does not take into account possible capital withdrawals, appreciations of existing stock, and, perhaps, accumulation abroad through reinvestment of earnings by existing enterprises.

Table 9. Japan's direct investments in the rest of the world between 1951 and 1978: accumulated total and its regional distribution.

	Value (U.S.$ million)	Percentage
Developed countries		
North America	6765	25.2
Europe	2961	11.0
Oceania	1285	4.8
Underdeveloped countries		
Central and South America	4373	16.3
East and Southeast Asia[a]	7505	28.0
South Asia[b]	163	0.6
Middle East	1971	7.4
Europe[c]	437	1.6
Africa	1138	4.2
Oceania	211	0.8

[a]Indonesia, Korea, Hong Kong, Philippines, Malaysia, Singapore, Thailand, Republic of China.

[b]All of Asia other than the countries making up East and Southeast Asia and the Middle East. Being a residual, these percentages may include small investments made in countries that do not fall into the accepted definition of South Asia.

[c]Investments in Europe other than those made in the U.K., Germany, France, The Netherlands, USSR, Belgium, and Switzerland — countries specified in the source.

Source: Toyo Keizai. 1980. Kaigai Shinshutsu Kigyo Soran (Japanese multinationals: facts and figures), 1980.

Japanese direct capital (Table 8), there does not seem to be any movement toward a greater concentration of Japanese PFI in developed countries, despite the achievement of industrial and technological maturity by Japan in recent years. Japan, perhaps, has better hosts among UDCs than among DCs for most of even the higher technology, more capital-intensive projects that it wishes to export.

Private foreign investment flows are known to be highly volatile. This is natural given the greater sensitivity of private capital to changes in profitability and "investment climate." Japan's history of PFI shows that annual PFI flows were more unstable than its ODA flows. Changes in host country conditions would have been partially responsible for this greater volatility of Japanese PFI, but even more important have been changes in domestic economic conditions within Japan. Whatever the causal factors, this underlines the well-known danger of the instability UDCs run into by depending heavily upon PFI for growth.

Other important limitations of PFI as a source of growth for UDCs can be seen by analyzing the regional distribution of Japanese direct investments overseas (Tables 9, 10). Direct overseas investment is a nonzero-sum game (Ady 1971) and unless an UDC is willing to offer its resources to foreign investors for unhampered profit-making and also is able to create the necessary confidence in their minds, PFI will never become a possible rich avenue of investment resources. Table 9 indicates that the Japanese stock of overseas investments in UDCs is heavily concentrated in three main regions. In descending order of importance they are East and Southeast Asia, Central and South America, and the Middle East. Overseas investments are flowing into areas where natural resources of crucial value to the foreign investors are available, in which case investment climate may be of secondary importance, and into areas where investment climate is deemed desirable by the investors concerned. When investment climate becomes of overriding importance, PFI flows are likely to be attracted into more developed countries than into less developed countries. This explains the negligible attraction of South Asia, underdeveloped Oceania, and non-oil producing underdeveloped Africa to Japanese (and also, perhaps, other) overseas capital. Japanese

Table 10. Japan's annual direct investments in underdeveloped countries, 1970–1978: regional breakdown (percentages).

	1970	1972	1973	1974	1975	1976	1977	1978
Central and South America	17.2	28.6	38.5	43.1	19.1	18.4	26.2	21.8
East and Southeast Asia[a]	61.6	40.5	46.5	44.7	55.5	54.5	49.2	47.4
South Asia[b]	0.7	0.3	0.2	0.4	1.2	0.1	0.4	0.1
Middle East	10.4	23.9	5.1	3.9	10.1	12.2	12.9	17.4
Europe[c]	4.1	2.2	2.8	3.5	2.9	2.0	2.5	4.1
Africa	5.2	3.4	5.0	3.4	9.9	11.9	8.0	8.0
Oceania	0.7	1.0	1.9	1.0	1.2	0.9	0.8	1.2

[a]Indonesia, Korea, Hong Kong, Philippines, Malaysia, Singapore, Thailand, Republic of China.

[b]All of Asia other than the countries making up East and Southeast Asia and the Middle East. Being a residual, these percentages may include small investments made in countries that do not fall into the accepted definition of South Asia.

[c]Investments in Europe other than those made in the U.K., Germany, France, The Netherlands, USSR, Belgium, and Switzerland — countries specified in the source.

Source: Toyo Keizai. 1980. Kaigai Shinshutsu Kigyo Soran (Japanese multinationals: facts and figures), 1980.

overseas investments in UDCs other than those in Central and South America, East and Southeast Asia, and the Middle East have been, throughout the 1970s, less than 15%. Often, this proportion was less than 10%. Private foreign investment seems to become a dependable source of growth only after a country has achieved some level of development; however, at very low levels of development a country seems to have to depend more heavily upon domestic resources or other forms of foreign resources. Even at a higher level of development, PFI is unlikely to be available equally for all UDCs. A high level of development is only part of the "acceptable investment climate."

A number of writers have attempted to develop theories to explain the phenomenon of overseas direct investment (e.g., various papers in Kindleberger 1970; Vernon 1971). These theories try to answer questions such as: What are the special advantages a foreign firm has over local firms in a host country? Why is foreign investment more common in some industries than others? At what level of development would an industry tend to establish foreign operations? (See Aliber (1970) for other relevant questions.) In pure theoretical writing, the attention given to the question of the determinants of the pattern of distribution of foreign investments by host countries is inadequate. The reason could very well be the fact that these determinants vary according to the source country of investments concerned and the nature of industries established through such investments.

In empirical studies (e.g., Yoshihara 1978) pertaining to Japanese investments abroad, the heavy concentration of these investments in East and Southeast Asia is explained through such factors as the geographical and cultural proximity and attractive foreign investment policies in these countries. When it comes to the question of the large flow of Japanese direct investments into Central and South America and the Middle East, geographical and cultural proximity as a factor determining the distribution of Japanese investments loses almost all of its potency. South Asia, for example, which is of negligible importance for Japanese investors, is clearly closer geographically and culturally to Japan than Central and South America and the Middle East.

During the 1970s, Japanese investments in South Asia were generally less than 1% of total Japanese investments in UDCs, the only exception being 1975. It is interesting to note the indifference of Japanese investors in this region, despite its size, in terms of population and total production, and very early Japanese industrial connections with Pakistan (K. Yoshihara, personal communication). Of the negligible Japanese direct investments in South Asia, India seems to be attracting the most attention. The repulsiveness of South Asia to Japanese investors is clear from the data, but to determine whether or not this is universal for all investing countries or is peculiar to Japan requires further investigation.

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Comparative Analysis of Technology Policies of ADIT Network Countries

Quazi H. Ahmed[1]

During the last ADIT work-in-progress meeting, held in Delhi, five of the six participating countries (i.e., Bangladesh, India, Korea, Philippines, and Sri Lanka) presented progress reports. The report of the Indian team contained only some basic statistics on the textile industry of India, due to the fact that work on the project had just begun. For this reason, only four country reports are considered in this comparative analysis. In most of these reports, policy issues have not been discussed explicitly and adequately. Moreover, there are wide differences between the countries with respect to methodological approach (e.g., measurement of performance and technical change, analysis, etc.). A complete and meaningful comparative analysis of the technology policy of Bangladesh with other ADIT network countries, therefore, cannot be carried out.

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Table 1. Process of accumulation of technological capacity in the ADIT network countries.

Country	Nature and extent of local efforts to accumulate technological capability	Accumulation through the transfer process
Bangladesh	College of textile technology produces textile technologists Some efforts toward imparting training from abroad and from local institutions	Locals have picked up the skills and experience to provide investment-related services from the textile machinery suppliers
Korea	Local efforts have been demonstrated by providing opportunities to local engineers and firms Positive steps have been taken to increase "human capital" through training and research Diffusion has been taking place through seminars, exhibitions, and the formation of professional societies	Training of local engineers and technicians by the technology supplier Technological collaboration with other foreign firms
Philippines[a]	Formal research and development activities in recent years Formation of a human resources division for imparting effective training	Visits by local engineers to the installations of potential technology suppliers Import of foreign experts as and when necessary "Mutual licencing agreements" with foreign firms (provides opportunity for free transfer of technical know-how from either party) Exchange of engineers and technicians for mutual benefit Joint ventures
Sri Lanka[a]	Fragmentary evidence of local training efforts	Training of local junior level technicians by the technology supplier Working closely with foreign experts

[a]The processes reported here have not been found in all of the mills in the sample. Therefore, these processes cannot be generalized.

Table 2. Degree of assimilation of imported production techniques in the ADIT network countries.

Country	Technoeconomic operating performance		Degree of structural integration		Intervintage technology change	
	Level	Trends	Current inputs	Investment goods and services	Minor	Radical
Bangladesh						
Cotton textiles	Low levels of performance	Decline of machine and labour productivity and capacity utilization	Some spare parts manufactured locally (not properly organized)	Some evidence of the use of locally manufactured machinery (not organized)	None	None
Korea						
Petrochemical sector (one plant)	NA	Increase in productivity indexes Reduction in ratio of input to output Some evidence of minor technical change, which resulted in a reduction in cost of output	Substantial portion of required spare parts manufactured locally (organized efforts)	Small portion of investment goods manufactured locally for expansion Investment-related services also provided from within the economy (since the construction of the second plant)	None	None
Nylon manufacturing (one plant)	Various problems during commissioning of the plant	Increase in labour productivity Reduction in cost per unit output Developed new products	None	None	None	None
Diesel-engine production	Problems during start-up phase	NA	NA	None	None	None
Tissue manufacturing	NA	NA	NA	Started with locally produced machinery (only the design was imported) Locally produced machinery also exported	NA	NA

Philippines						
Integrated textile mills (four mills)	Low capacity utilization (A-Tex) High ratio of idle to installed machines (A-Tex)	NA	Use of locally manufactured spare parts (C-Tex)	Redesigning of imported machinery (Rami-Tex) Portion of investment-related services provided by locals (B-Tex)	Process improvement (Rami-Tex) Modification of imported machinery (C-Tex)	None
Synthetic fibre manufacture (five mills)	Problems during start-up Low capacity utilization	Decline of labour productivity (Texfibre) Increase in wastage rate (Texfibre)	None	None	None	None
Sri Lanka						
Cotton textiles	Low level of capacity utilization	NA	NA	NA	NA	NA
Synthetic textiles	Low level of capacity utilization	NA	Evidence of locally manufactured accessories (reportedly of poor quality)	Evidence of locally manufactured (simple) textile machinery	NA	NA
Pulp and paper	Unsatisfactory performance	Some improvements in performance achieved (with the help of hired overseas consultants)	None	None	None	None

NA = information not available

In spite of these constraints, however, an attempt to assess the degree of assimilation of imported techniques and the process of accumulation of technological capabilities and make some tentative comments about the technological policies of these countries has been made. Tables 1 and 2 show the comparative pictures of the process of accumulation and the degree of assimilation of local technological capabilities respectively.[2]

From Table 2, it appears that South Korea assimilated more imported techniques than the other countries. The Philippines also shows some success in this respect. Sri Lanka and Bangladesh have shown low degrees of assimilation. Table 1 indicates that South Korea had the best structure for accumulating technological capability through organized efforts toward local research and development and in-plant training. Benefits have also been derived from overseas training of engineers. In the case of Sri Lanka (for the warp-knitting process), it appears that there have been some efforts in this direction but with apparently less success. The situation in Bangladesh is somewhat similar to that of Sri Lanka. In the Philippines, there was some degree of research and development activity (in Rami-Tex). There was also an effort to impart effective training to operatives and the services of foreign experts seem to have played some role in the process of assimilation.

It is not clear from the country reports which technology policies helped or hindered local technological capability development. However, it appears that Korea has a policy to support and encourage local efforts for such activities. In the Sri Lankan case, import liberalization policies seem to have affected the product market and also the process of local technological capability accumulation. Import liberalization has put local manufacturers of textile machinery and parts in an uncompetitive situation. For example, due to the imposition of very low duties (5%) on imported textile machinery, local manufacturers are being forced out of business. Also, there seems to have been no technology policy for the pulp and paper industry.

In the case of Bangladesh, there seems to have been no explicit technology policy regarding the cotton textile sector. There is, apparently, no conscious effort to improve local technological capabilities and the low level of assimilation in order to become more self-reliant.

In conclusion, it should again be stressed that this analysis is incomplete due to the nature of the information available from the work-in-progress reports of these countries. It does, however, provide a tentative analytical framework for such comparisons and should, therefore, be used only for that purpose.

[2]The structure of the comparison is based on the analytical framework developed and used for the analysis of the performance of the Bangladesh textile industry.

Workshop Conclusions

When the ADIT research project was first proposed it had the following set of objectives:

(1) Examine the pattern of technology transfer and adaptation at the firm level in various industrial sectors.

(2) Explore the way that imported technology changes (both for a sector and the enterprise) manufacturing, training, and commercial perspectives.

(3) Propose policy changes that allow technology absorption and adaption to cohere more appropriately to national goals.

To determine whether or not these objectives were met, the workshop participants were divided into three working groups, each group being assigned one of the objectives for discussion. The following are the findings of the working groups based upon the question discussed.

Is there evidence of a pattern of technology transfer and adaption at the firm level in the various industrial sectors? If so, what is it and how could it be classified?

The main elements of technology importation in the various sectors appear to be: electronics, product; petrochemicals steel, process; machinery manufacture, product; textiles, equipment (spinning and weaving), product (garments); and pharmaceuticals, product. Initially, transfers are made in packaged form but with time, substitution from local sources occurs.

The mode of acquisition selection depends upon the type of organization involved. Multinational organizations tend to procure technology from their parent firms. In the public sector, technology is purchased through government-to-government agreements based on credit aid programs. Donors usually require international consultants to undertake feasibility studies, and plant design and procurement is limited to specific countries or groups of countries. In the private sector, technology acquisition usually occurs through joint ventures or licencing arrangements in which the recommendations of the foreign counterparts are often accepted. Small-scale enterprises usually acquire technology that is available within the country. In this regard, they may seek the assistance of local research and development or consulting firms. In all cases, the type of skills transferred to these various organizations is mainly related to operational phases.

The nature of the technology acquired seems to be conditioned by several factors. Market structure affects the level of technology transferred, e.g., operating in a competitive market, particularly abroad, provides an impetus to acquire higher level technology. Management capability, particularly its attitude toward risk, also influences the choice, e.g., public sector managers, for whom job security may be a major concern, tend to depend upon foreign consultants and imported technology, although both may be available within the country. Sociocultural and sociopolitical factors also influence the nature of the technology transferred. For instance, Singapore's difficulty in manning the construction sector — high risk work (low status is not attractive to

Singaporeans — hence their move toward high-technology industries); political stability — foreigners may be unwilling to invest large sums of money in sophisticated technology based industries.

Some of the problems affecting technology transfer include a lack of information on available technologies, reluctance of enterprises to invest in high-risk research and development work, and the lack of local capability for technological development change.

Does imported technology change the manufacturing, training, and commercial perspectives of the firm or the sector? If so, how and in what particular ways?

The first impact of technology in any sector generally was upon manufacturing as far as embodied technology and its operating knowledge and techniques were concerned, but most developing countries resorted to continued import and dependence upon imported embodied technology. Accompanying the later imports were only marginal changes in manufacturing perspectives; in many cases none at all.

Training carried from sector to sector. Rigorous training normally took place during the initial import stage but later the new firms were able to pirate manpower from existing industries and to some extent assimilation occurred when the quantum of imports became large enough to warrant a technical training institute in the public (generally) or private sector.

In certain cases, entrepreneurs expanded their production facilities by duplicating them with imported machinery but utilizing manpower from their own firms; for instance, the assistant manager may have been promoted to manage the new concern and his subordinate promoted in the parent firm, etc. Training in such industries took place through the guidance and supervision of expatriates in the initial stages, later followed by on-the-job training of local personnel. In sophisticated technologies and highly capital-intensive concerns, where the risk was high, entrepreneurs insisted that the supplier of technology train their manpower and assist them in erection, installation, and start-up.

In the public sector, manufacturing, training, and commercial perspectives are different from those of the private sector. In the public sector, risk-taking is smaller; therefore, enterprises insist upon more technical cooperation and rely upon standard technology imported from reliable and proven suppliers. The private sector is more cost conscious and willing to take on more risks. Concerns in Korea, however, are an exception. In Korea, there exist a large number of dynamic intellectuals on the management side of public enterprises who are willing to take risks and even innovate.

Commercial perspectives differ between consumer-goods industries and capital-goods industries; public enterprises and private enterprises; suppliers' markets and buyers' markets; and export-oriented firms and local market oriented firms. In the case of foreign equity participation, marketing perspectives are imported and supervised in the initial stages by expatriates (not true for Korea).

In all developing countries there are able managers and marketing specialists and several institutes that can impart training in management and marketing skills.

In many cases where governments ban the import of foreign products, thereby restricting competition from foreign manufacturers, and the local people are more price conscious than quality conscious, manufacturing and commercial perspectives are oriented toward low-cost and low-quality products.

Restrictive clauses imposed by suppliers of technology may alter commercial perspectives, e.g., marketing may be restricted to a certain region. .

As a rule, suppliers of technology do not train manpower unless contracts call for it. Training is usually requested in either: (1) very sophisticated technologies that are new to the country or (2) highly capital-intensive technologies involving a large amount of risk. Diffusion of these types of technology in expansion of the sector is quite limited.

Training of key skilled personnel was undertaken in the case of new and very sophisticated technologies but very seldom were the "trainers" trained or a set of directions framed for their usage.

Local market size is a constraint for imported technologies, particularly in the capital-goods sector. In such cases there is a need to change the commercial perspectives of the importer of technology. Generally, however, any change that occurs is due entirely to indigenous effort without any direct import of know-how.

Governments in various developing countries have tried to stress the importance of appropriate village-level technology and change manufacturing perspectives but with little success. Some technology in this respect has been imported through the United Nations. Through various policies, most governments have attempted to promote training and export of locally manufactured, value-added items. This has been tried through laws for compulsory on-the-job training and export rebates.

Manufacturing perspectives, which exist in most developing countries (particularly with respect to research and development in innovation, adaptation, quality control, and product design), were not absorbed by most of the developing countries.

What evidence do the studies contain that would make the importation of technology more consistent with national goals?

There is much in common in the national goals of the countries represented in the studies presented at the workshop. Generally, these goals could be said to be economic growth of at least 5–6%, stability, and promotion of social justice. More precisely, in the achievement of these national goals, the emphasis is on generation of increasing employment opportunities. Also, a major problem these countries have been faced with is that relating to the severe foreign exchange constraint.

The studies reveal that in arriving at arrangements for importation of technology, the countries have been constrained by the foreign exchange situation. This has often led to these countries being compelled to accept packages in which technology and credit are tied together. Again, in the choice of the level of technology, quite often the countries had to choose technologies that were comparatively more labour intensive. In countries such as India, paralleling the development of capital-intensive technologies, national policies have favoured the fostering of the small-scale labour-intensive sector, which provides greater employment opportunities. The handloom and khadi industries in India have received favoured treatment in pursuance of this policy.

Also implicit in the studies is the desire on the part of the countries to reduce the continuing dependence upon imported technology and foreign technologists. Generally, there is pressure to accelerate the development of self-reliance in technology. One step toward this goal involves local nationals taking over from foreign technologists. This implies that in the context of national goals, the goal of technology policy is the achievement of national self-reliance. Attempts to achieve this goal are being made through the process of national utilization of imported technology and its adaptation to local needs. This process of adaptation is facilitated by the "learning-by-doing" process and in this way it is hoped that the imported technology will be absorbed.

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